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               USER'S GUIDE. COMPUTER PROGRAM FOR DESIGN AND ANALYSIS OF SHEET--ETC(U)
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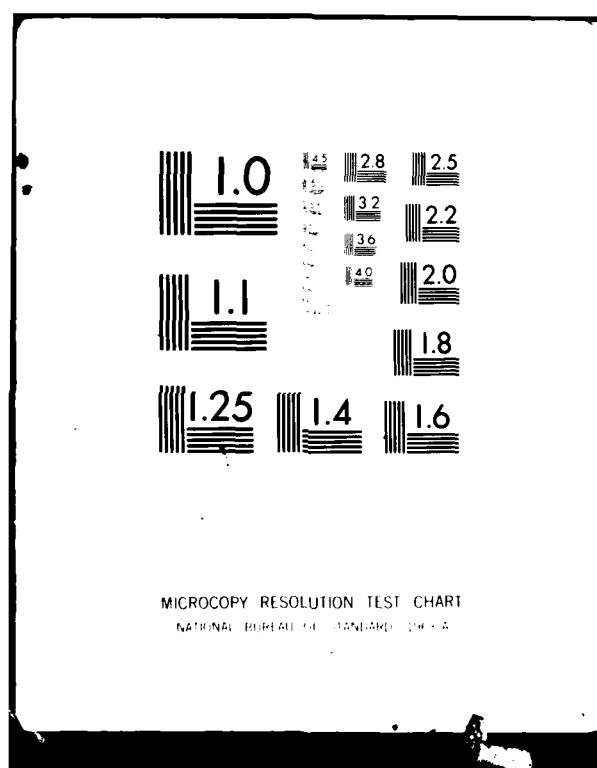UNCLASSIFIED   WES-INSTRUCTION-K-81-2   NL

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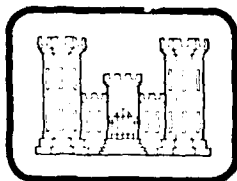
INSTRUCTION REPORT K-81-2

USER'S GUIDE: COMPUTER PROGRAM FOR DESIGN AND ANALYSIS OF SHEET PILE WALLS BY CLASSICAL METHODS (CSHTWAL)
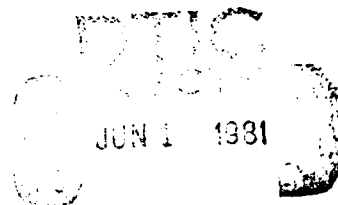
Report 2

INTERACTIVE GRAPHICS OPTIONS

by

Michael E. George

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DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

SUBJECT: Instruction Report K-81-2, User's Guide: Computer Program for
           Design and Analysis of Sheet Pile Walls by Classical Methods
           (CSHTWAL), Report 1 and Report 2

All Corps Elements with Civil Works Responsibilities

1. The subject user's guide documents a computer program named CSHTWAL that
can be used for analyzing and designing cantilever and singly anchored sheet
pile walls. The program specification for CSHTWAL was developed by the
Computer-Aided Structural Engineering (CASE) Task Group for Pile Structures
and Substructures. As is the goal with all CASE tasks, the intent is to make an
organized, cost-effective computer solution available to the Corps' designers
for use when the need arises.

2. Engineers will be readily able to tell by the description of the program
and by the examples given in the report of the applicability toward their
needs. Detailed documentation of the program may be obtained from the Engineer-
ing Computer Programs Library (ECPL) of the U.S. Army Engineer Waterways
Experiment Station (WES), Vicksburg, MS.

3. We strongly encourage the use of these programs where applicable throughout
the Corps.

FOR THE CHIEF OF ENGINEERS:

LLOYD A. DUSCHA
Chief, Engineering Division
Directorate of Civil Works

Description of Program

CSHTWAL, called X0031 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) library, performs design and/or analysis of either a cantilever or an anchored sheet pile wall. The program uses classical soil mechanical procedures for determining the required depth of penetration of a new wall or assesses the factor of safety for an existing wall. Seepage effects are included in a simplified manner in the program.

Coding and Data Format

CSHTWAL is written in FORTRAN and is operational on the following systems:

<u>a</u>. U. S. Army Engineer Waterways Experiment Station (WES) Honeywell G635.

<u>b</u>. Office of Personnel Management Honeywell 6000 Series at Macon, Ga.

<u>c</u>. Boeing Corporation's CDC CYBER 175.

Data can be input either interactively from the user's terminal or from a prepared data file with line numbers. When data are input from the terminal during execution, the program provides prompting messages to indicate the type and amount of input data to be provided. Output can be obtained at the terminal, written to a permanent file for listing at the terminal at a later date, or directed to a mainframe line printer. The program also has interactive graphics capabilities to allow the user to display the input geometry with applied loads and/or the output including moment, shear, deflection, and pressure diagrams.

How To Use CSHTWAL

A short description of how to access the program on each of the three systems is provided below. It is assumed that the user knows how to sign on the appropriate system before trying to use CSHTWAL. In the example initiation of execution commands below, all user responses are underlined, and each should be followed by a carriage return.

WES G635 and Macon systems

After the user has signed on the system, the two system commands FORT and NEW get the user to the level to execute the program. Next, the

81 6 01 160

user issues the run command

RUN WESLIB/CORPS/X0031,R

to initiate execution of the program. The program is then run as des-
cribed in this user's guide. The data file should be prepared prior to
issuing the RUN command. An example of initiation of execution is as
follows, assuming a data file had previously been prepared:

HIS SERIES 600 ON 09/18/80 AT CHANNEL 5647
USER ID - ROKACASESHT
PASSWORD - MMEREXAREXXOMX
SYSTEM? FORT NEW
READY
*RUN WESLIB/CORPS/X0031,R

Boeing system

The log-on procedure is followed by a call to the CORPS procedure file

OLD,CORPS/UN=CECELB

to access the CORPS library. The file name of the program is used in
the command

CALL,CORPS,X0031

to initiate execution of the program. An example is:

WELCOME TO THE BCS NETWORK
YOUR ACCESS PORT IS SWY 55
SELECT DESIRED SERVICE: EKS1
80/09/18. 13.30.0.
EKS1 175G.N0460.68BA 80/09/14.DS-0   02.39.05. 80/09/16.
USER ID: CER0C1
PASSWORD -
IXKOXEXXOM

Continued

                                (Continued)

2

*

```
C>OLD,CORPS/UN=CECELB
C>CALL,CORPS,X0031
```

How To Use CORPS

The CORPS system contains many other useful programs which may be cata-
logued from CORPS by use of the LIST command. The execute command for
CORPS on the WES and Macon systems is:

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

on the Boeing system, the commands are:

```
OLD,CORPS/UN=CECELB
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

3

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Instruction Report -81-2	2. GOVT ACCESSION NO. AD-A099 519	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) USER'S GUIDE: COMPUTER PROGRAM FOR DESIGN AND ANALYSIS OF SHEET PILE WALLS BY CLASSICAL METHODS (CSHTWAL) Report 2, Interactive Graphics Options		5. TYPE OF REPORT & PERIOD COVERED Report 2 of a series
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Michael E. George		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Automatic Data Processing Center P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Office, Chief of Engineers, U. S. Army Washington, D. C. 20314		12. REPORT DATE March 1981
		13. NUMBER OF PAGES 80
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This report was prepared under the Computer-Aided Structural Engineering (CASE) Project. A list of published CASE reports is printed on the inside of the back cover.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer graphics   Steel sheet piles
Computer programs
CSHTWAL (Computer program)
Sheet piling

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This user's guide describes the interactive graphics options of computer program "CSHTWAL." CSHTWAL can be used for design and analysis of sheet pile walls using classical methods. The graphics capabilities allow the user to interactively display the input geometry with applied loads and/or the output including moment, shear, deflection, and pressure diagrams. A Tektronix 4014/4054 graphics terminal is required to use these capabilities.

Use of CSHTWAL itself is discussed in detail in Report 1 of this series.

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Preface

This user's guide presents documentation of the interactive graphics options of computer program "CSHTWAL." CSHTWAL can be used for the design and analysis of sheet pile walls using classical methods. The work in writing the interactive graphics options for the program and this user's guide was accomplished with funds provided to the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., by the Office, Chief of Engineers, U. S. Army (OCE), under the Computer-Aided Structural Engineering (CASE) Project.

Specifications for CSHTWAL were provided by members of the CASE Task Group on Sheep Pile Structures. The following were members of the Task Group (though all may not have served for the entire period) during the period of development of the program:

> Mr. Terry Soupos, North Central Division (Chairman)
> Mr. Richard Albert, Detroit District
> Mr. James Bigham, New Orleans District
> Mr. Walter Green, Nashville District
> Mr. Tom McGee, Nashville District
> Mr. Louis Mendell, New York District
> Mr. T. Samuelson, Seattle District
> Mr. Ken Waddell, Huntington District

During the latter stages of development of the program and this user's guide, the Sheet Pile Structures Task Group was combined with the Pile Foundations Task Group and renamed the Pile Structures and Sub-Structures Task Group. This new Task Group then assumed responsibility for the program. The Pile Structures and Sub-Structures Task Group is composed of the following members:

> Mr. James Bigham, New Orleans District (Chairman)
> Mr. Roger Brown, South Atlantic Division
> Mr. Dick Chun, Pacific Ocean Division
> Mr. Walter Green, Nashville District
> Mr. Joe Hartmann, St. Louis District
> Mr. Roger Hoell, St. Louis District
> Mr. Tom Mudd, St. Louis District (former Chairman)
> Mr. Phil Napalitano, New Orleans District
> Mr. Arthur Shak, Pacific Ocean Division
> Mr. Ralph Strom, Portland District

1

Documentation of CSHTWAL itself is próvided in WES Instruction Report K-81-2, "User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL); Report 1: Computational Processes," by William P. Dawkins. The interactive graphics options and this user's guide were written by Mr. Michael E. George, Research and Development Software Group, Automatic Data Processing (ADP) Center, WES. Appendix A to this user's guide and the example presented in Appendix B are from Report 1.

Dr. N. Radhakrishnan, Special Technical Assistant, ADP Center, WES, and CASE Project Manager, coordinated and monitored the work with assistance provided by Mr. Paul K. Senter, Computer-Aided Design Group (CADG), ADP Center. Mr. H. Wayne Jones, CADG, supported the Task Group in compiling program specifications. He and Ms. Dorothy B. May, CADG, helped in converting the program to the WES, Macon, and Boeing computers. Messrs. Donald M. Dressler and Rixby Hardy, Civil Works Directorate, were OCE points of contact. Mr. Donald L. Neumann was Chief of the ADP Center during the development of the program and preparation of this user's guide.

Directors of WES during this period were COL J. L. Cannon, CE, and COL N. P. Conover, CE. Technical Director was Mr. F. R. Brown.

Contents

Conversion Factors, Inch-Pound to Metric (SI) Units of Measurement

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
inches	2.54	centimetres
kip (1000 lb force)-feet	1.355818	kilonewton-metres
pound (force)-feet	1.355818	newton-metres
pound (force)-inches	0.1129848	newton-metres
pounds (force)	4.448222	newtons
pounds (force) per square foot	47.88026	kilopascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
pounds (mass) per foot	1.488164	kilograms per metre

USER'S GUIDE: COMPUTER PROGRAM FOR DESIGN

AND ANALYSIS OF SHEET PILE WALLS

BY CLASSICAL METHODS (CSHTWAL)

INTERACTIVE GRAPHICS OPTIONS

Introduction

1. This user's guide describes the interactive graphics options
of computer program "CSHTWAL." CSHTWAL can be used for design and anal-
ysis of sheet pile walls using classical methods. The graphics capabil-
ities allow the user to interactively display the input geometry with
applied loads and/or the output including moment, shear, deflection, and
pressure diagrams. A Tektronix 4014/4054 graphics terminal is required
to use these capabilities.

2. Use of CSHTWAL itself is discussed in detail in Report 1 of
this series.* In the remainder of this user's guide, that document will
be referred to as "Report 1." This report only addresses the interac-
tive graphics options of CSHTWAL. The input guide from Report 1 is
provided again in Appendix A for easy reference.

Input Geometry

3. The user may display the input geometry in both the analysis
and the design modes for either an anchored or a cantilevered wall. If
any loads have been applied to the right-side soil surface or to the
wall, a plot displaying these loads will also be output. If no loads
are applied, only the input geometry plot will be displayed.

4. To enter the input graphics portion of the program, the user
must respond with YES to the following question:

---

* Dawkins, W. P. 1981. "User's Guide: Computer Program for Design
   and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL);
   Report 1: Computational Processes," Instruction Report K-81-2, U. S.
   Army Engineer Waterways Experiment Station, Vicksburg, Miss.

```
DO YOU WANT A PLOT OF INPUT GEOMETRY?
ENTER 'YES' OR 'NO'
=
```

5. Having answered with a YES response, the user must now enter
the distances (in feet) from the left and right sides of the wall to set
up the display boundary limits for the input geometry plots:

```
ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
     LEFT SIDE      RIGHT SIDE
       (FT)            (FT)
=
```

It should be pointed out that the distance from the wall on the left
side need not a symmetric to the distance from the wall on the right
side. However, nonsymmetric input, such as the distance from the wall
on the left side = 50 ft* and on the right side = 100 ft, may cause some
of the plot to be "clipped."

6. Upon entering the two values and a carriage return, the screen
will be erased and the plots displayed. A bell will ring at the end of
each plot, and execution will be suspended to allow the user to make a
hardcopy if desired. To resume execution of the program, the user
simply enters a carriage return.

7. An example of the input geometry interactive sequence is pre-
sented below. Unless otherwise stated, only the first character of the
word is required whenever the program asks for a work response. The
input and analysis parts of this example (problem "ANCH1" from Report 1)
are shown in Appendix B.

```
DO YOU WANT A PLOT OF INPUT GEOMETRY?
ENTER 'YES' OR 'NO'
=YES
```

                    (The screen is erased.)

---

* A table of factors for converting inch-pound units of measurement to
  metric (SI) units is presented on page 4.

```
*** I N P U T   S E L E C T E D ***
    ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
        LEFT SIDE        RIGHT SIDE
          (FT)             (FT)
=-100.,100.
```

> (The screen is erased and the plot in
> Figure 1 is displayed. A bell rings
> and execution is temporarily halted
> so that the user can take a hardcopy.
>
> Upon entering a carriage return, the
> screen is again erased. Since there
> is a uniform load on the right-side
> soil surface, the plot in Figure 2 is
> displayed. A bell rings suspending
> execution so that a hardcopy can be
> taken.)

8.   If a carriage return is entered, the screen is erased and the user is given the opportunity to replot the input geometry and applied loads with different display boundary limits (different scale):

```
DO YOU WANT TO REPLOT WITH NEW DISTANCES FROM WALL?
ENTER 'YES' OR 'NO'
=
```

If the user responds with YES, he is returned to the question in paragraph 5. If he responds with NO, the input geometry sequence is exited, and he is returned to the main program to continue execution.

9.   It should be noted that if the user has input any of the applied loads described in Appendix A, paragraphs 11-13, those loads will be displayed on a plot similar to that shown in Figure 2.

10.   Figures 3-10 show examples of applied loads displayed with the input geometry. These plots do not correspond to any problem discussed in this report. They are used here for illustration only.

Output Results

11.   The graphics options enable the user to display moments, shears, deflections, and pressures for either an anchored or a cantilevered wall. The user may also redisplay the input geometry plots

7
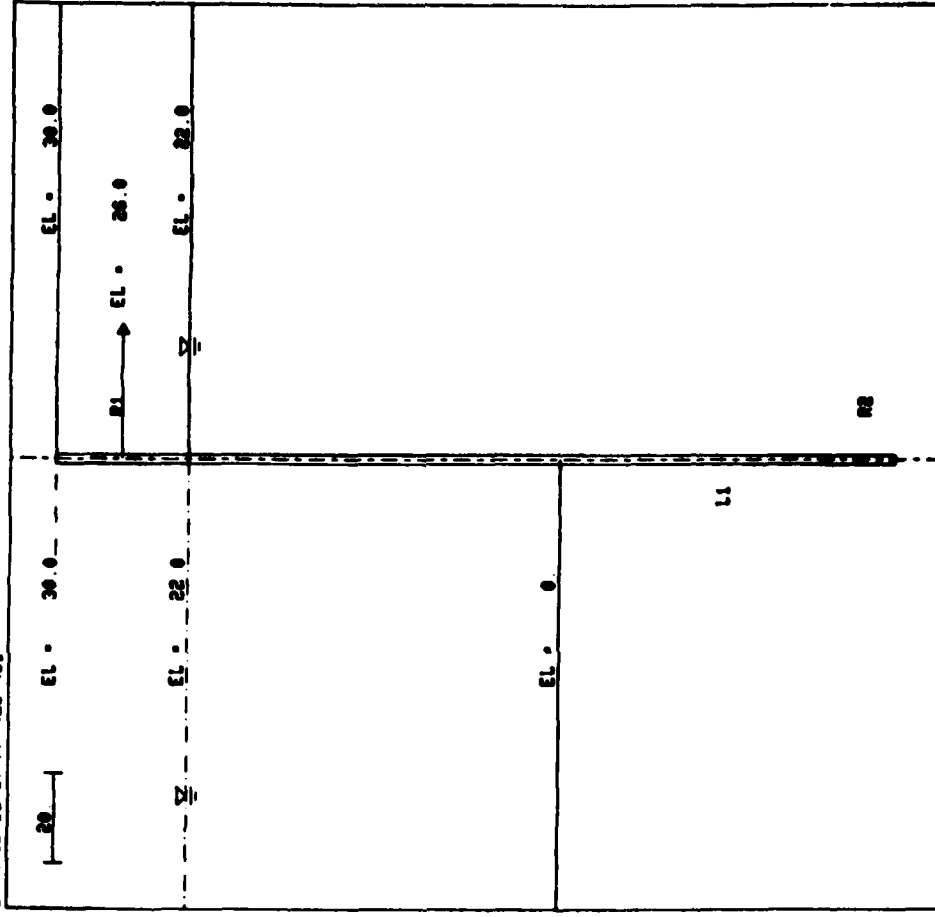
Figure 1. Input geometry plot for problem "ANCH1"

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 429-431

LEGEND
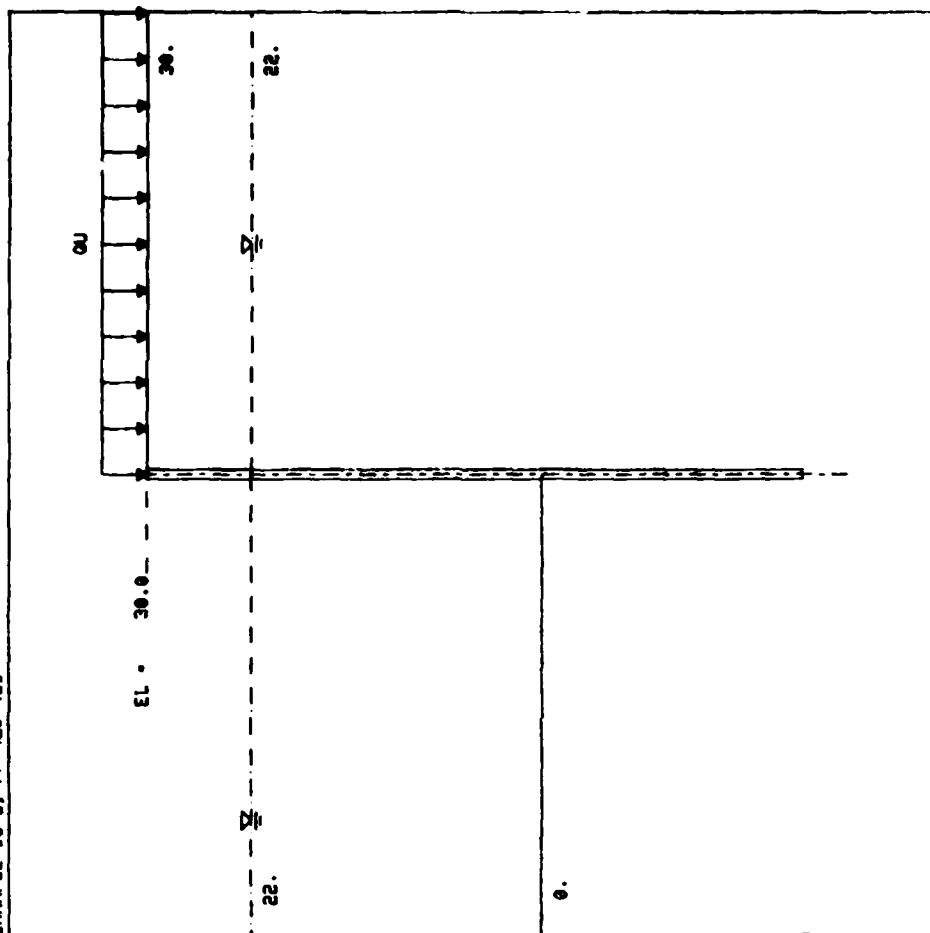
QU = 500.0000 PSF

Figure 2. Input geometry with applied loads for problem "ANCH1"

Figure 3. Example plot of uniform load on top soil surface

Figure 4. Example plot of strip load on top soil surface

Figure 5. Example plot of ramp load on top soil surface

Figure 6. Example plot of triangular load on top soil surface

Figure 7. Example plot of vertical point loads on top soil surface

EXAMPLE PROBLEM FOR HORIZONTAL LINE LOADS ONLY

LEGEND

H1 = 100.0000 PLF
H2 = -100.0000 PLF
H3 = 100.0000 PLF
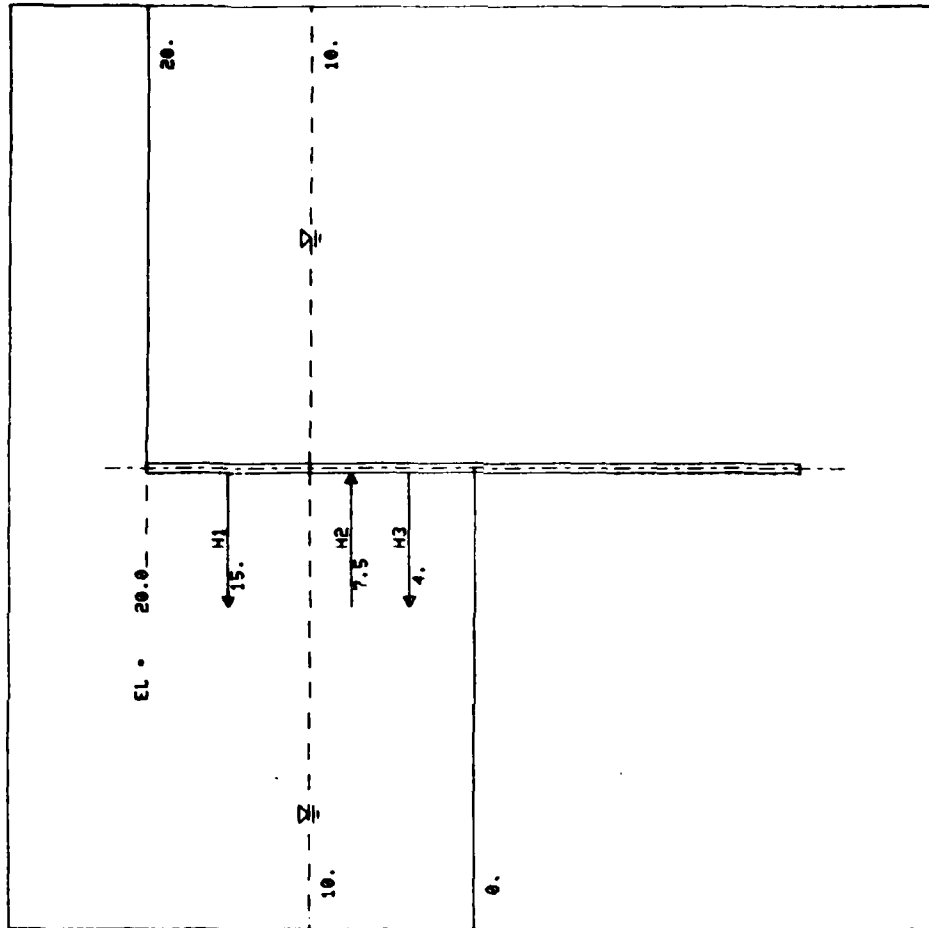
Figure 8. Example plot of horizontal line loads applied to the wall

15
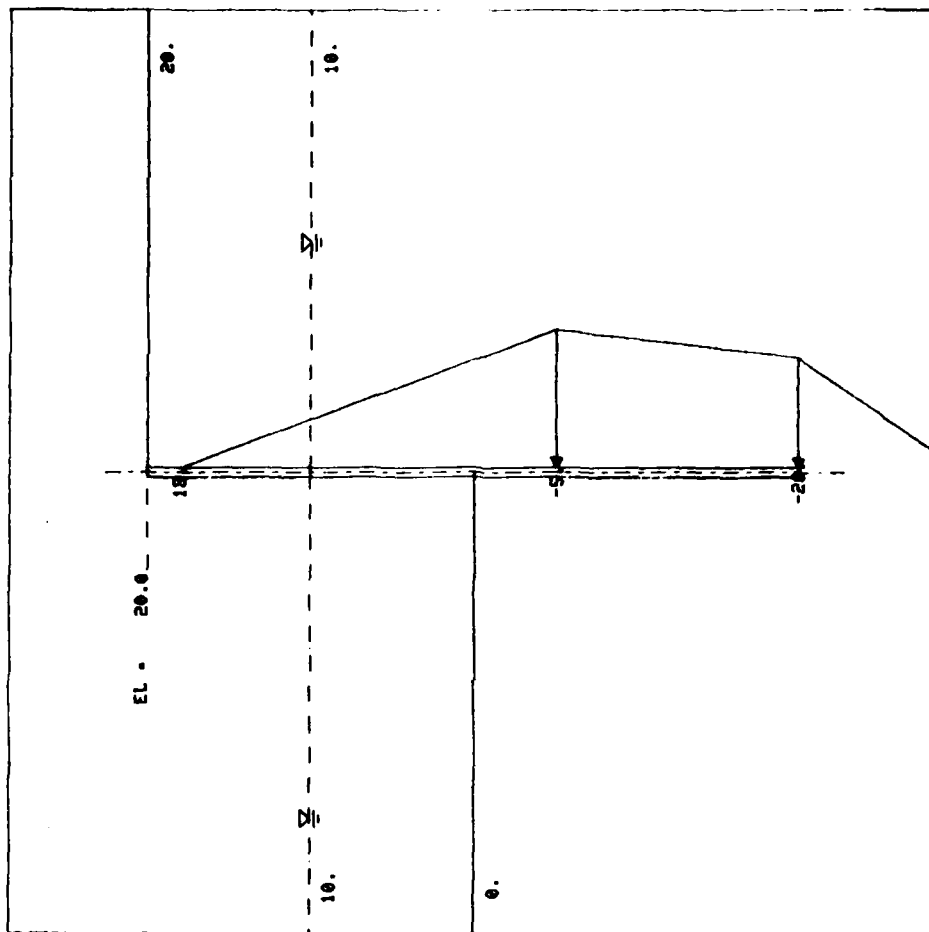
Figure 9. Example plot of horizontal pressure loads applied to the wall
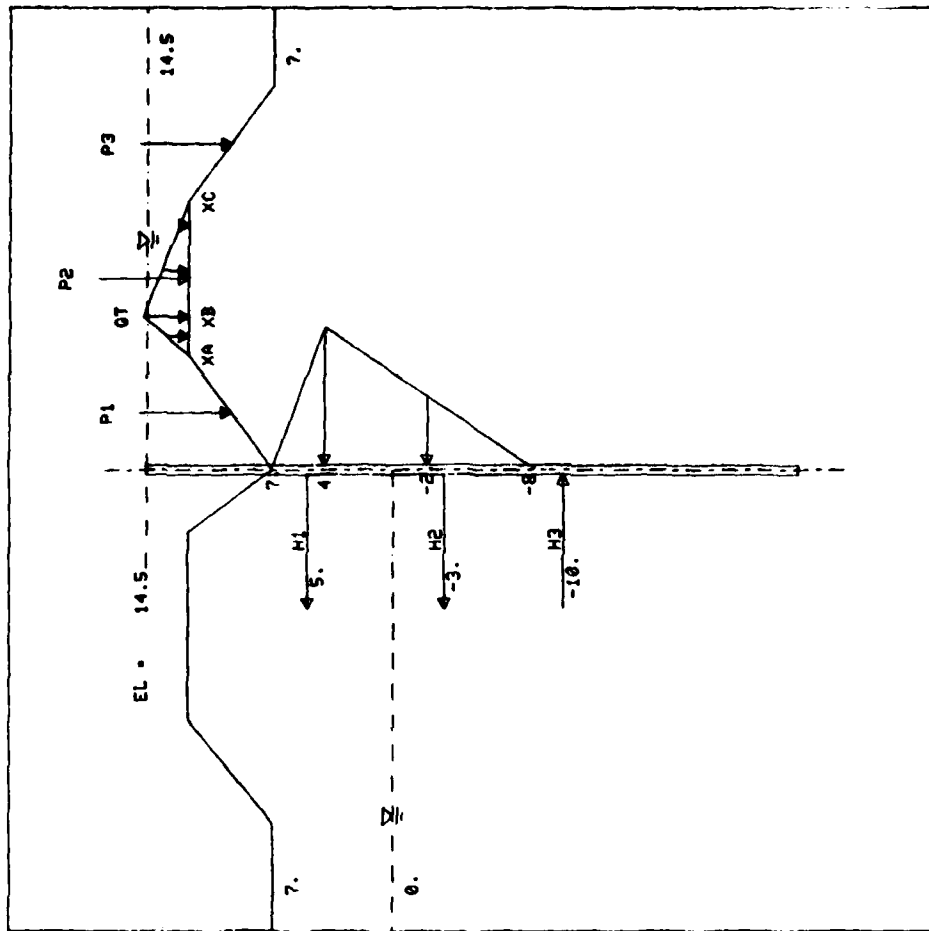
Figure 10. Example plot of multiple load applied on top soil surface and to the wall

with the bottom elevation of the wall which was calculated in the design run. For example, if the user began his problem in the design mode, the original input geometry plots will not show an elevation at the bottom of the wall. Upon completion of the solution, a bottom of the wall is defined. The user can then obtain these same input geometry plots with the bottom elevation of the wall labelled.

12. To enter the output graphics portion of the code, the user must respond to the following question:

```
    DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
    ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'
=
```

If the user responds with NEITHER, the output graphics sequence is omitted, and the user is returned to the main program to continue execution. If he responds incorrectly to this question, it will be repeated and he will be given another opportunity to enter a correct response. A response of BOTH or GEOMETRY gives the user the opportunity to replot his input geometry.

13. If the user is solving an anchored wall problem, he must select the desired method of analysis for which the input geometry will be displayed. The following question is asked:

```
    RESULTS ARE AVAILABLE FOR FOLLOWING METHODS OF ANALYSIS
        FREE EARTH : ENTER 'FR' ON CUE
        FIXED EARTH: ENTER 'FI' ON CUE
        EQUIV BEAM : ENTER 'EB' ON CUE
        EQUAL MOM  : ENTER 'EM' ON CUE
        TERZAGHI   : ENTER 'TE' ON CUE
    ENTER METHOD FOR WHICH GEOMETRY PLOT IS DESIRED
=
```

If the user responds incorrectly, the question will again be repeated and he will be given another opportunity to enter a correct response.

14. If the user selects a method for which results were not processed, a message will be printed stating this. For example, if the user selected the TERZAGHI method of analysis and it had not been processed, the following would be output:

18

RESULTS ARE NOT AVAILABLE FOR METHOD 'TE'

    15. The user is then given the opportunity to select another method:

```
DO YOU WANT RESULTS PLOTTED FOR ANOTHER METHOD?
ENTER 'YES' OR 'NO'
=
```

A response of YES returns the user to the question in paragraph 13. A NO response exits the output graphics sequence of the code and returns the user to the main program to continue execution.

    16. When the selection of a method which has been processed is made, the same sequence of prompts discussed previously in paragraphs 4-8 will be issued.

    17. If the user is solving a cantilevered wall problem, the questions discussed in paragraphs 13-15 will be omitted and only the input sequence in paragraphs 4-8 will be issued.

    18. The following is an example (again for problem "ANCH1" in Appendix B) of the input geometry redisplay interactive sequence:

```
DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'
=BOTH

              (The screen is erased.)

*** I N P U T   S E L E C T E D ***
RESULTS ARE AVAILABLE FOR FOLLOWING METHODS OF ANALYSIS
      FREE EARTH : ENTER 'FR' ON CUE
      FIXED EARTH: ENTER 'FI' ON CUE
      EQUIV BEAM : ENTER 'EB' ON CUE
      EQUAL MOM  : ENTER 'EM' ON CUE
      TERZAGHI   : ENTER 'TE' ON CUE
ENTER METHOD FOR WHICH GEOMETRY PLOT IS DESIRED
=FR
ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
      LEFT SIDE      RIGHT SIDE
         (FT)           (FT)
=-100.,100

              (The screen is again erased and
              Figures 11 and 12 are displayed.
```

19

EL = 30.0

EL = 30.0

EL = 26.0

EL = 22.0

EL = 22.0

R1 →

EL = 26.0

EL = 0

EL = -8.5

L1

R2

LEFTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
L1	0	30.0	128.5	20.0

RIGHTSIDE SOIL PROPERTIES

LAYER	C	PHI	GAMMA	DELTA
R1	0	30.0	105.0	20.0
R2	0	30.0	128.5	20.0
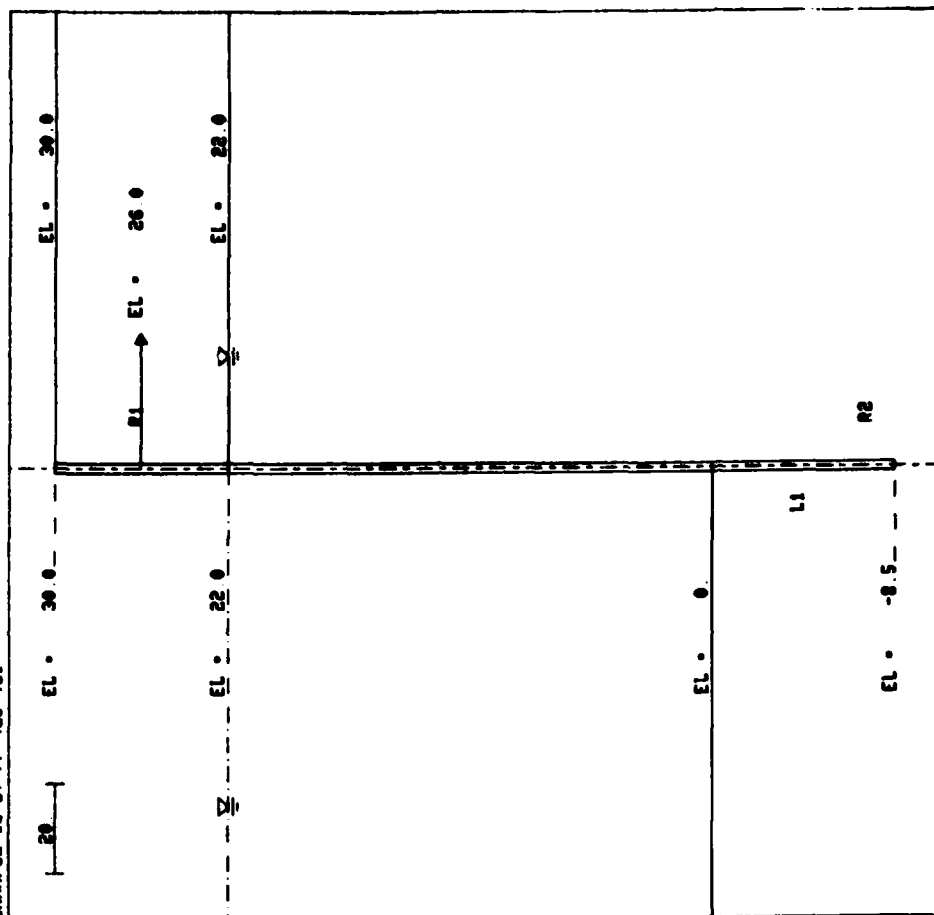
Figure 11. Input geometry redisplay for problem "ANCH1"
(Free earth method of analysis)

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 429-431

LEGEND

QU = 500.0000 PSF
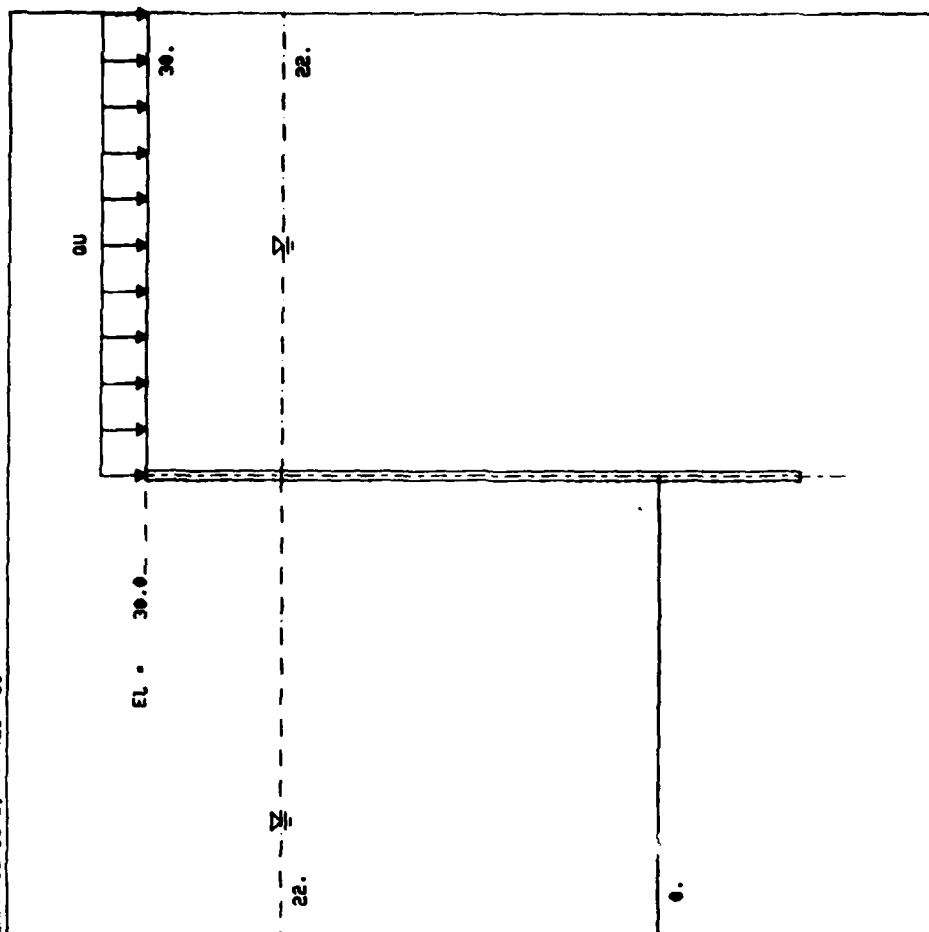
Figure 12. Input geometry applied loads redisplay for problem "ANCH1"
(free earth method of analysis)

21

As before, a bell rings and
execution is temporarily suspended
so that hardcopies can be made of
each plot. To continue execution,
simply enter a carriage return and
the applied loads will be redis-
played. There is a pause to allow
the user to make hardcopies if
desired. To continue, hit the
carriage return and the screen is
erased and another method of
analysis may be selected.)

```
    DO YOU WANT TO REPLOT WITH NEW DISTANCES FROM WALL?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT GEOMETRY PLOTTED FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
=YES
    RESULTS ARE AVAILABLE FOR FOLLOWING METHODS OF ANALYSIS
        FREE EARTH : ENTER 'FR' ON CUE
        FIXED EARTH: ENTER 'FI' ON CUE
        EQUIV BEAM : ENTER 'EB' ON CUE
        EQUAL MOM  : ENTER 'EM' ON CUE
        TERZAGHI   : ENTER 'TE' ON CUE
    ENTER METHOD FOR WHICH GEOMETRY PLOT IS DESIRED
=FI
    ENTER DISTANCE FROM WALL TO WHICH PLOT IS DESIRED
        LEFT SIDE        RIGHT SIDE
            (FT)            (FT)
=-100.,100
```

(The screen is erased and Figures 13
and 14 are displayed. Since the
input graphic redisplay for other
methods of analysis is not desired,
the input interactive sequence is
exited.)

```
    DO YOU WANT TO REPLOT WITH NEW DISTANCES FROM WALL?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT GEOMETRY PLOTTED FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
=NO
```

19. If the user responds with GEOMETRY to the question in para-
graph 12, only the input geometry redisplay will be executed. Control
is then transferred to the main program for continued execution.

22
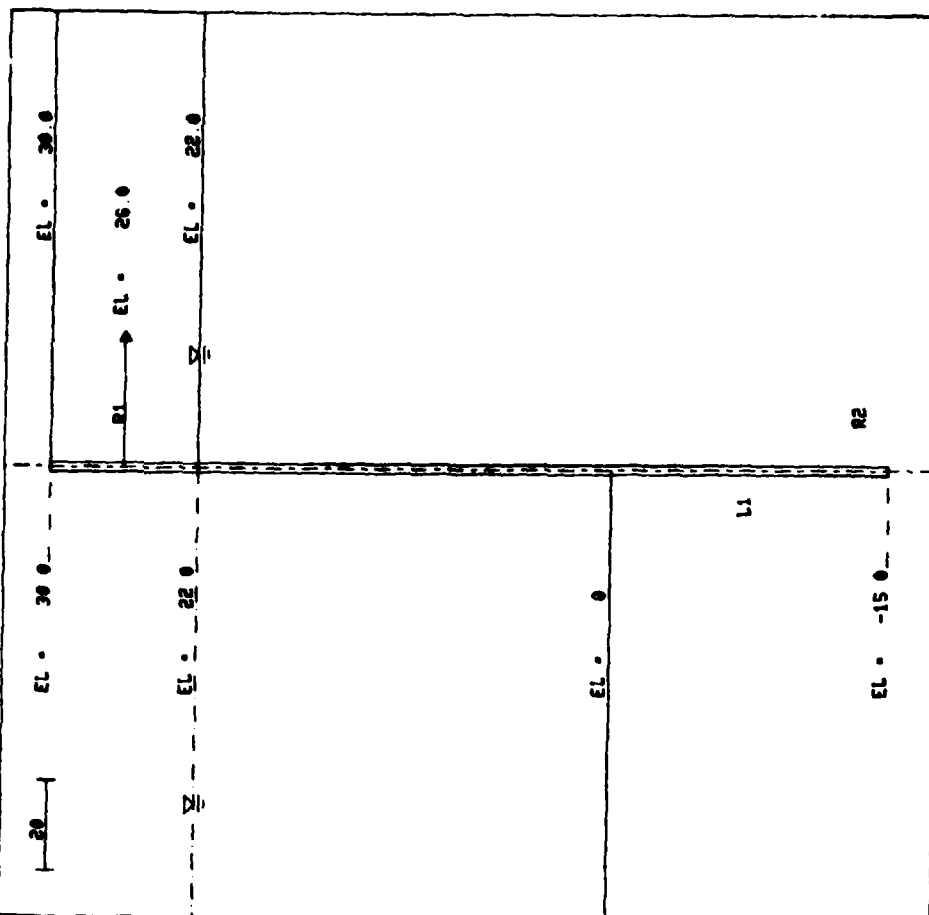
Figure 13. Input geometry redisplay for problem "ANCH1" (fixed earth method of analysis)

Figure 14. Input geometry applied loads redisplay for problem "ANCH1"
(fixed earth method of analysis)

20. A response of BOTH to the question in paragraph 12 will exe-
cute the input geometry redisplay as discussed earlier and then direct
the display of shear, moment, deflection, and pressure plots for the
methods of computation available. A response of RESULTS to the question
will execute only the plotting of the shear, moment, deflection, and
pressure diagrams. It should again be pointed out that, for cantilevered
wall design, the method of solution option is _not_ requested by the
program.

21. For anchored wall designs, the following is output:

*** O U T P U T   S E L E C T E D ***

Then, the question in paragraph 13 is again asked to determine the method
of analysis for which to make the shear, moment, deflection, or pressure
plots. The user then has the option to select the plot to be displayed:

```
ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
     1=BENDING MOMENT
     2=SHEAR
     3=SCALED DEFLECTION
     4=NET PRESSURE
=
```

If he incorrectly responds to the above question, it is repeated.

22. Once a correct response is given, the minimum and maximum com-
puted values of the desired plot parameter are printed. The user must
then enter a minimum and a maximum value to set up his display limits.
The minimum value must be less than the minimum computed value printed.
The maximum value must be greater than the maximum computed value printed.
For example, if the user selects the bending moment to be plotted, the
following illustrates this feature:

```
MIMIMUM AND MAXIMUM BENDING MOMENT RESULTS
     MINIMUM =     -1522.
     MAXIMUM =     76537.
ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
MUST BE LESS THAN MINIMUM AND GREATER THAN
MAXIMUM RESULTS, RESPECTIVELY
     MINIMUM     MAXIMUM
=-85000.,85000.
```

For symmetric plots, the user should input the minimum equal to the negative of the ximum. Nonsymmetric plots may be made, but care should be taken that some of the graphics output not be "clipped."

23. The user must next enter a desired interval value for labelling the horizontal axes (always positive):

    ENTER INTERVAL FOR LABELLING VALUES ON AXES
    =

The screen is then erased and the plot displayed. Upon completion of the plot, a bell rings and execution is temporarily suspended to allow the user to make a hardcopy. To resume execution, he simply enters a carriage return.

24. The user is next given the opportunity to replot with new minimum and maximum limits (different scale):

    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
    =

A YES response returns the user to the number code selection question in paragraph 21.

25. A NO response gives the user the opportunity to select another plot from the same method of analysis:

    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
    =

A response of YES returns the user again to the number code selection question in paragraph 21.

26. If the user responds with NO, he has the opportunity to select another method to be plotted:

    DO YOU WANT PLOTS FOR ANOTHER METHOD?
    ENTER 'YES' OR 'NO'
    =

26

A response of YES returns him to the method of selection question in para-
graph 13. A NO response exits the output graphics portion of the code.

27. The following is an example (again for problem "ANCH1") of the
output options for one available method:

```
*** O U T P U T   S E L E C T E D ***
    RESULTS ARE AVAILABLE FOR FOLLOWING METHOD OF ANALYSIS
         FREE EARTH : ENTER 'FR' ON CUE
         FIXED EARTH: ENTER 'FI' ON CUE
         EQUIV BEAM : ENTER 'EB' ON CUE
         EQUAL MOM  : ENTER 'EM' ON CUE
         TERZAGHI   : ENTER 'TE' ON CUE
    ENTER METHOD FOR WHICH RESULTS ARE TO BE PLOTTED
=FR
```

> (The free earth method of analysis is
> selected. The screen is erased.)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3=SCALED DEFLECTION
         4=NET PRESSURE
=1
    MINIMUM AND MAXIMUM BENDING MOMENT RESULTS
         MINIMUM =      -1522.
         MAXIMUM =      76537.
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
    MUST BE LESS THAN MINIMUM AND GREATER THAN
    MAXIMUM RESULTS, RESPECTIVELY
         MINIMUM     MAXIMUM
=-85000.,85000.
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=20000.
```

> (The bending moment plot is selected.
> A symmetric plot is desired and a tic
> interval of 20,000 lb-ft is entered.
> The screen is erased and a bending
> moment diagram is plotted as shown in
> Figure 15. A bell rings and execution
> is temporarily halted for the user to
> make a hardcopy, if desired. If he
> enters a carriage return, the screen
> is erased and another plot is selected
> for the same method.)

27

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL

MOMENT (LB-FT)
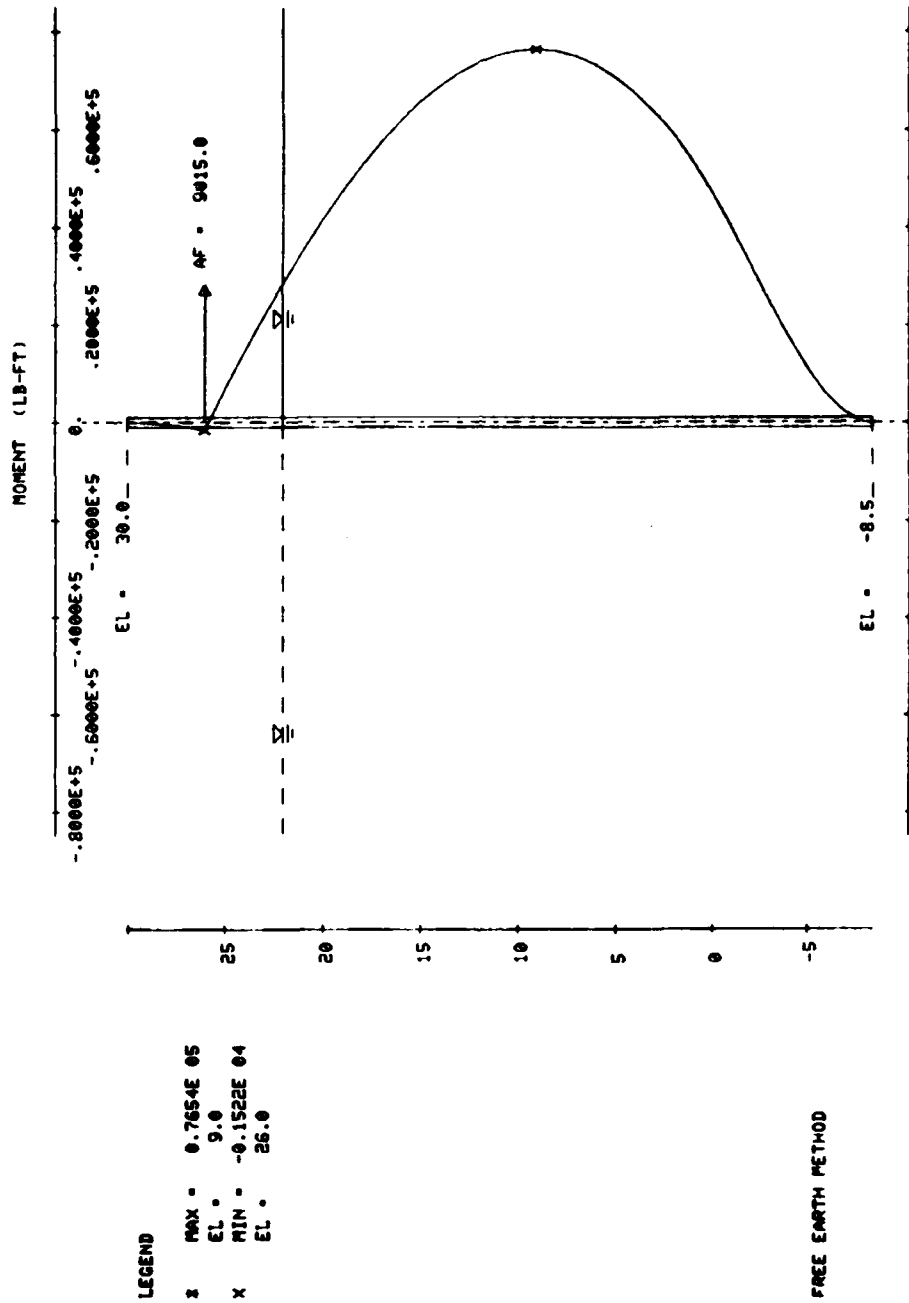
Figure 15. Output bending moment results for problem "ANCH1"
(free earth method of analysis)

28

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=YES


             (The screen is erased.)


    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3= SCALED DEFLECTION
         4=NET PRESSURE
=2
    MINIMUM AND MAXIMUM SHEAR RESULTS ARE
         MINIMUM =       -7586.
         MAXIMUM =        8171.
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
    MUST BE LESS THAN MINIMUM AND GREATER THAN
    MAXIMUM RESULTS, RESPECTIVELY
         MINIMUM      MAXIMUM
=-10000.,10000.
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=5000.
```

                              (The shear plot is selected. The ap-
                              propriate display limits and tic inter-
                              val are entered. The screen is erased
                              and a shear diagram is made as shown in
                              Figure 16. A bell again rings and exe-
                              cution is temporarily halted to make a
                              hardcopy. After the user enters a
                              carriage return, the screen is erased
                              and another plot is selected for the
                              same method.)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=YES


             (The screen is erased.)
```

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL

SHEAR (LB)

EL = 30.0 - - -

EL = -8.5 - - -

LEGEND

☒   MAX =   0.8171E 04
     EL =   26.0
✕   MIN =   -0.7586E 04
     EL =   -2.2

POINTS OF ZERO SHEAR

EL =   -8.5
EL =   9.0
EL =   26.0
EL =   30.0

FREE EARTH METHOD

Figure 16.   Output shear force results for problem "ANCH1"
(free earth method of analysis)

30

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
          1=BENDING MOMENT
          2=SHEAR
          3=SCALED DEFLECTION
          4=NET PRESSURE
=3
    MINIMUM AND MAXIMUM SCALED DEFLECTIONS ARE
          MINIMUM =  -5.76E Ø9
          MAXIMUM =   1.56E 1Ø
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
          MINIMUM     MAXIMUM
=-2.5E+1Ø 2.5E+1Ø
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=1.ØE+1Ø
```

> (The scaled deflection plot is selected.
> the appropriate display limits and tic
> interval are entered. The screen is
> erased and scaled deflection is displayed
> as shown in Figure 17. Execution is
> again halted for hardcopy purposes. Once
> the user enters a carriage return, the
> screen is erased and the option to replot
> is taken.)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=YES
```

> (The screen is erased.)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
          1=BENDING MOMENT
          2=SHEAR
          3=SCALLD DEFLECTION
          4=NET PRESSURE
=3
    MINIMUM AND MAXIMUM SCALED DEFLECTIONS ARE
          MINIMUM =  -5.76E Ø9
          MAXIMUM =   1.56E 1Ø
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
          MINIMUM     MAXIMUM
=-5.ØE+1Ø 1Ø.E+1Ø
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=4.ØE+1Ø
```

> (The scaled deflection plot is again
> selected. New display limits and tic
> interval are entered (nonsymmetric).

31
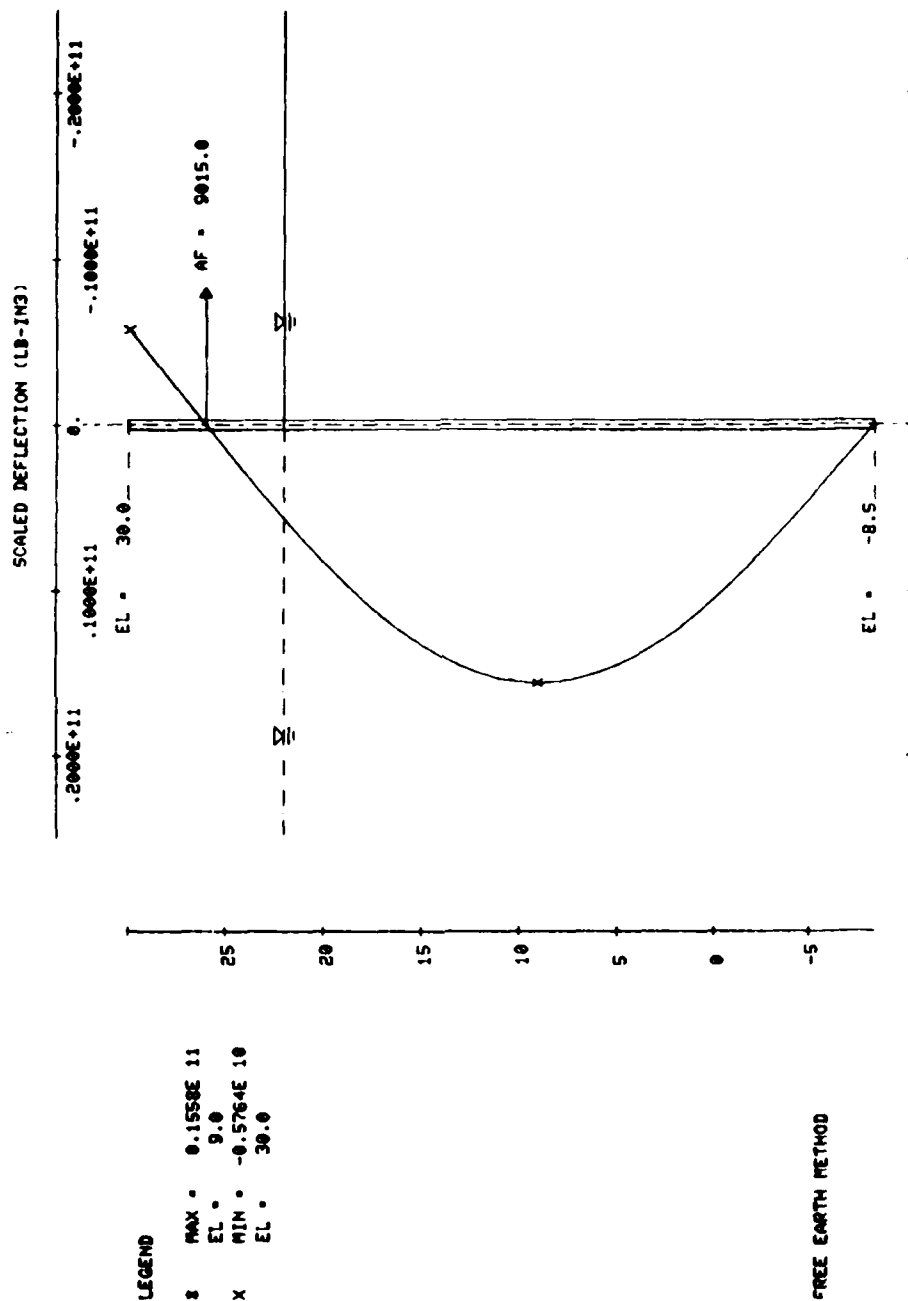
Figure 17. Output of scaled deflection for problem "ANCH1" (free earth method of analysis)

> The screen is erased and scaled deflection is replotted as shown in Figure 18. Again, a hardcopy can be taken if desired. After a carriage return is entered, the screen is erased and another plot is selected for the same method of analysis.)

```
    DO YOU WANT TO REPLOT RESULTS WITH NEW
    MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
    ENTER 'YES' OR 'NO'
=NO
    DO YOU WANT OTHER RESULTS PLOTTED?
    FOR THE SAME METHOD
    ENTER 'YES' OR 'NO'
=YES
```

> (The screen is erased.)

```
    ENTER NUMBER CODE FOR RESULTS TO BE PLOTTED
         1=BENDING MOMENT
         2=SHEAR
         3=SCALED DEFLECTION
         4=NET PRESSURE
=4
    MINIMUM AND MAXIMUM NET PRESSURE RESULTS ARE
         MINIMUM =    -2411.54
         MAXIMUM =      830.10
    ENTER MINIMUM AND MAXIMUM LIMITS FOR AXES.
    MUST BE LESS THAN MINIMUM AND GREATER THAN
    MAXIMUM RESULTS, RESPECTIVELY
         MINIMUM      MAXIMUM
=-3500.,3500.
    ENTER INTERVAL FOR LABELLING VALUES ON AXES
=1000.
```

> (The net pressure plot is selected. The appropriate display limits and tic interval are entered. The screen is erased and a net pressure diagram is displayed as shown in Figure 19. A hardcopy can again be taken if desired. After the user enters a carriage return, the screen is erased and the output graphics sequence is exited.

33

PROBLEM - ANCH - ANCHORED WALL DESIGN - GRANULAR SOIL

SCALED DEFLECTION (LB-IN3)
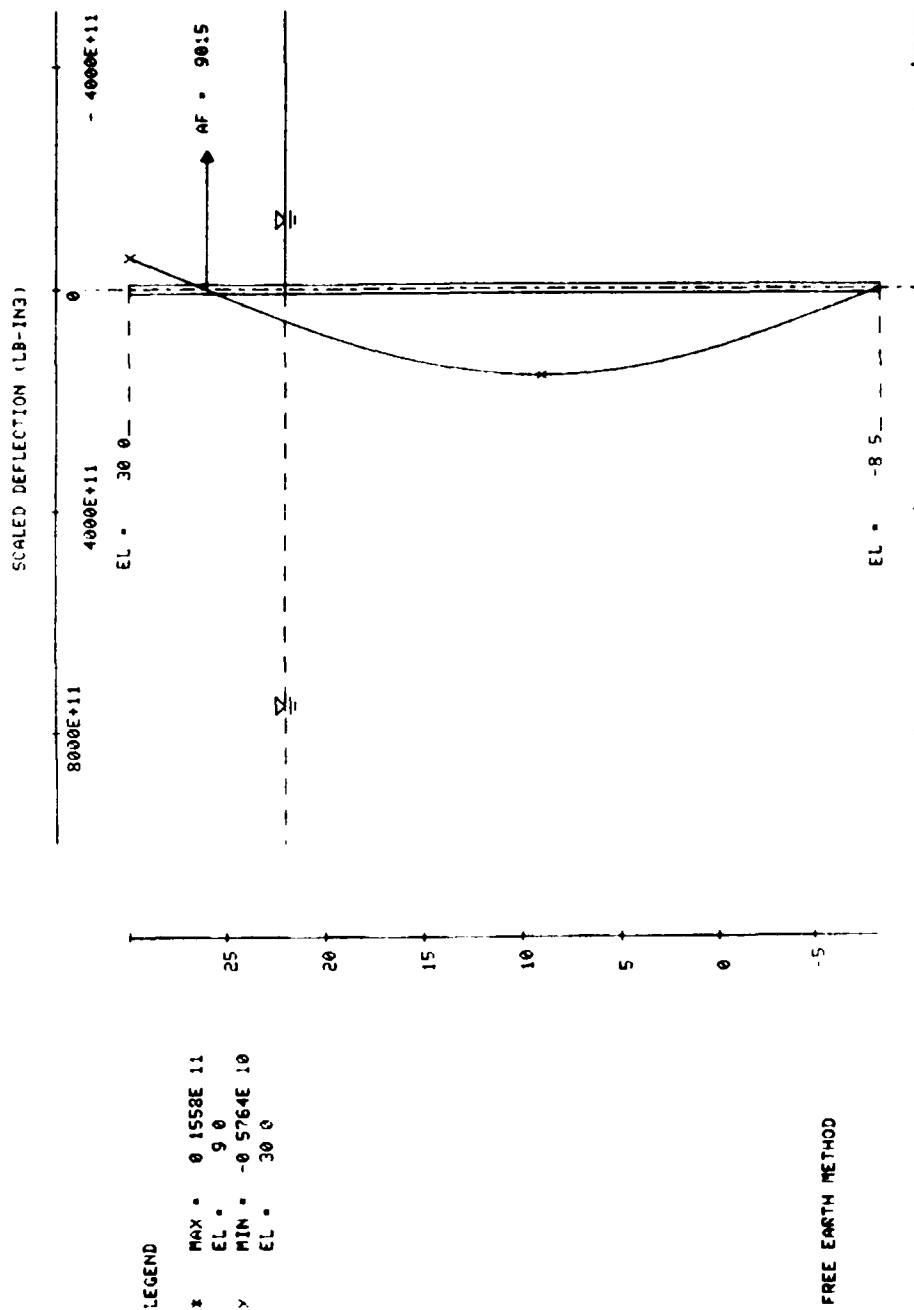
Figure 18. Replot of scaled deflection for problem "ANCH1" (free earth method of analysis)

34

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL

PRESSURE (PSF)

LEGEND

* MAX = 0.8301E 03
  EL = 0
× MIN = -0.2412E 04
  EL = -8.5
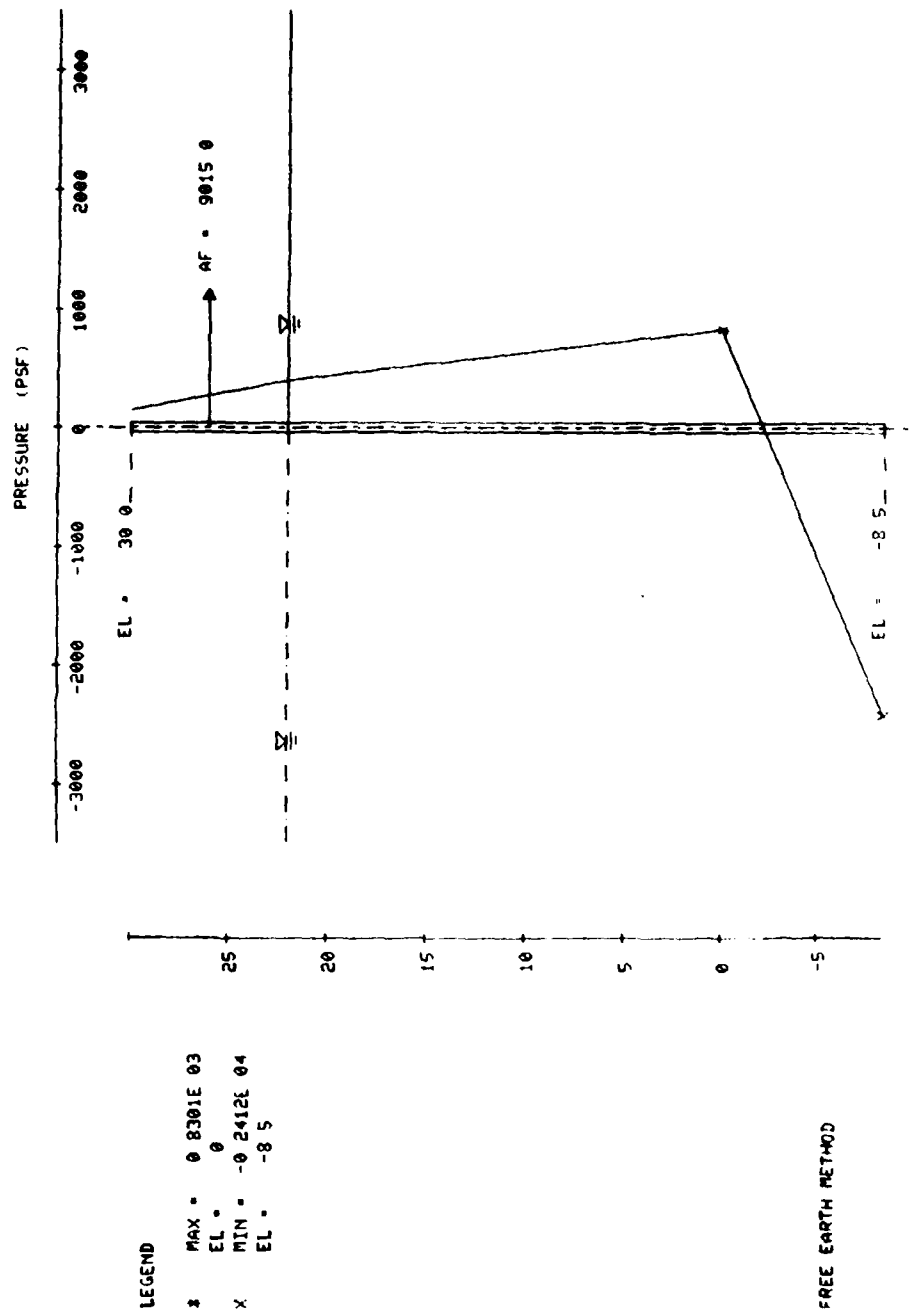
FREE EARTH METHOD

Figure 14. Output of net pressure for problem "ANCH1"
(free earth method, Article 19)

35

```
      DO YOU WANT TO REPLOT RESULTS WITH NEW
      MINIMUM AND MAXIMUM LIMITS FOR PLOT AXES?
      ENTER 'YES' OR 'NO'
=NO
      DO YOU WANT OTHER RESULTS PLOTTED?
      FOR THE SAME METHOD
      ENTER 'YES' OR 'NO'
=NO
      DO YOU WANT PLOTS FOR ANOTHER METHOD?
      ENTER 'YES' OR 'NO'
=NO
```

(The user is then returned to the main
problem for continued execution.)

Appendix A: Input Data Guide

Notes and General Requirements

for Wall Description

1. Coordinate System

   a. The wall is assumed to be vertical.

   b. All elevations and distances are assumed to be given in feet.

   c. All vertical dimensions are given as elevations with respect to an arbitrary datum. Elevations increase toward the top of the wall.

   d. All horizontal dimensions are given as the positive distance in feet from the wall, increasing away from the wall. There are no negative horizontal distances.

   e. Impending rotation of the wall is assumed to be counter-clockwise for cantilever walls and clockwise for anchored walls.

2. Top of Wall

   a. The elevation of the top of the wall must be at or above the intersection of the rightside surface with the wall (i.e., TOPEL $\geq$ SURELR(1), Figure A2).

3. Anchor

   a. For an anchored wall, a horizontal anchor is assumed.

   b. The anchor must be at or below the elevation of the top of the wall (i.e., ANCHEL $\leq$ TOPEL, Figure A1).

4. Bottom of Wall

   a. The elevation of the bottom of the wall, BOTEL (Figure A1) is determined in the "Design" mode.

   b. The elevation of the bottom of the wall, BOTEL (Figure A1) must be provided in the "Analysis" mode.

5. Rightside Soil Surface (Figure A2)

   a. The general rightside surface is assumed to be described by pairs of coordinates giving the elevation and distance from the wall for up to fifteen (15) points on the surface. The surface between adjacent points is assumed to be a straight line.

      a(1) The first point is at the intersection of the surface and the wall. The elevation of the first point must be at or below the top of the wall.

      a(2) If only one (1) surface point is provided, a horizontal rightside surface is assumed.

A2

Figure A1. Data names for wall, water, and anchor
elevations and horizontal line loads
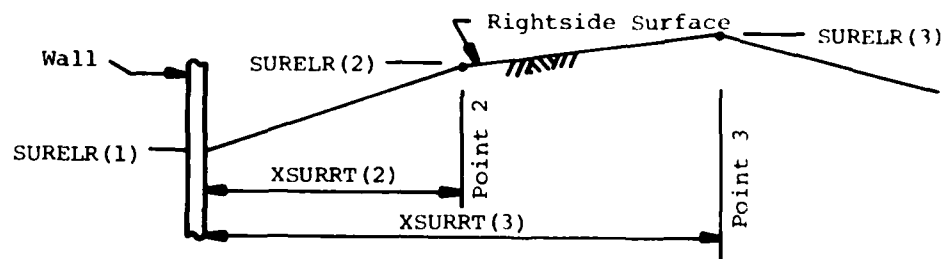
(a) Rightside Surface Coordinates
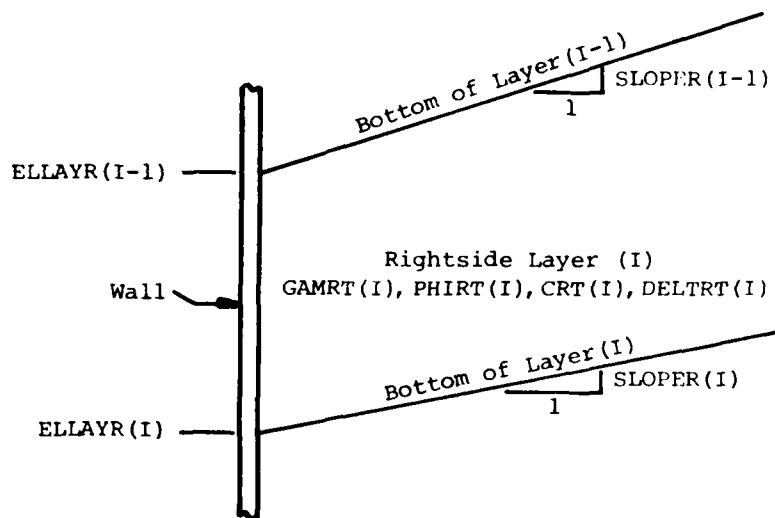
(b) Rightside Layer Data

Figure A2. Data names for rightside soil

A4

a(3) The rightside surface is assumed to extend horizontal-
ly ad infinitum beyond the last surface point provided.

a(4) The slope of every segment of the surface must be less
than or equal to the effective angle of internal fric-
tion for the top rightside soil layer.

7. Rightside Soil Layers (see Figure A2)

a. The soil on the rightside of the wall is assumed to be com-
posed of one (1) to fifteen (15) soil layers. Soil proper-
ties as follow are assumed to be constant within each layer.

a(1) Unit weight, GAMRT, (PCF) input is assumed to be for
unsubmerged soil. Submerged unit weight is determined
from the position of the water surface on the right-
side.

a(2) Angle of internal friction, PHIRT, (DEG) must be
greater than or zero if CRT (see next paragraph) is
equal to zero.

a(3) Cohesion, CRT, (PSF) must be greater than zero if
PHIRT is equal to zero.

a(4) Angle of wall friction, DELTRT, (DEG).

b. Adjacent soil layers are assumed to be separated by a
straight line which extends ad infinitum from the wall.
The boundary between layers is associated with the layer
above and is described by

b(1) The elevation, ELLAYR, at which the boundary inter-
sects the wall.

b(2) The slope, SLOPER, of the wall expressed in feet of
rise per foot. A positive slope extends up away from
the wall.

b(3) Layer boundary lines may not intersect (i.e., must be
parallel or diverge away from the wall).

c. The last soil layer provided is assumed to extend ad infini-
tum downward.

8. Leftside Soil Surface (see Figure A3)

a. The general leftside surface is assumed to be described by
pairs of coordinates giving the elevation and distance from
the wall for up to fifteen (15) points on the surface. The
surface between adjacent points is assumed to be a straight
line.

a(1) The first point is at the intersection of the surface
and the wall and must be at or below the top of the
wall.

a(2) If only one (1) surface point is provided, a horizon-
tal surface is assumed.

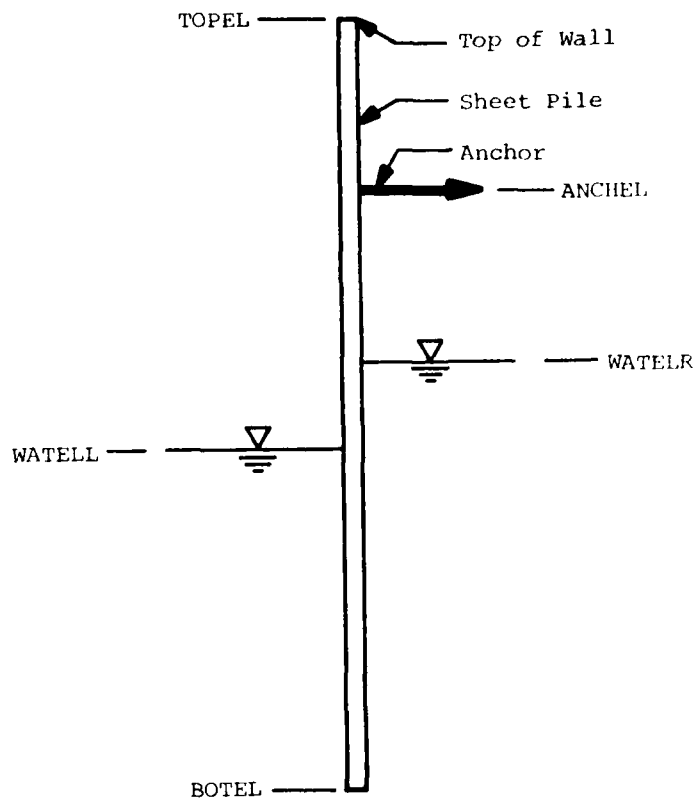a(3) The leftside surface is assumed to extend horizontally
ad infinitum beyond the last surface point provided.

A5
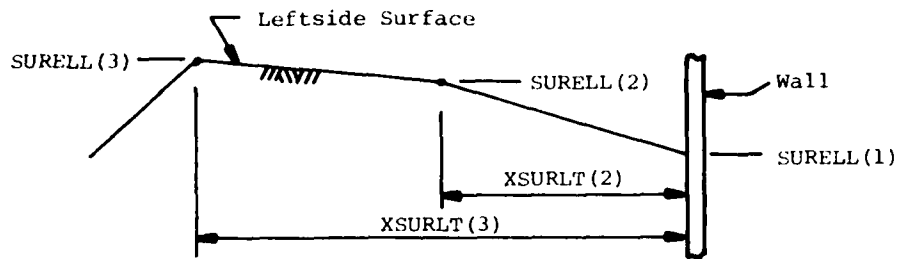
(a) Leftside Surface Coordinates
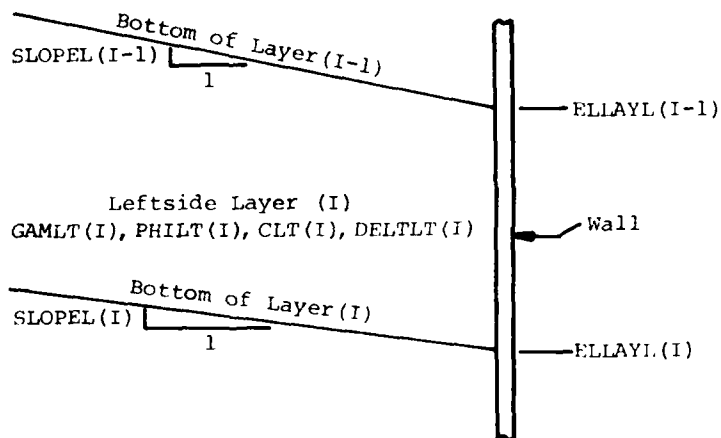
(b) Leftside Layer Data

Figure A3. Data names for leftside soil

    a(4) The slope of every segment of the leftside surface
        must be less than or equal to the effective angle of
        internal friction for the top leftside soil layer.

9. Leftside Soil Layers (see Figure A3)

    a. The soil on the leftside of the wall is assumed to be com-
        posed of one (1) to fifteen (15) soil layers. Soil proper-
        ties as follow are assumed to be constant within each layer.

        a(1) Unit weight, GAMLT, (PCF) is assumed to be for unsub-
            merged soil. Submerged unit weight will be determined
            from the position of the leftside water surface.

A6

          a(2)   Angle of internal friction, PHILT, (DEG) must be greater than zero if CLT (see next paragraph) is equal to zero.

          a(3)   Cohesion, CLT, (PSF) must be greater than zero if PHILT is equal to zero.

          a(4)   Angle of wall friction, DELTLT, (DEG).

10. Water Data

    a. When seepage effects are not included, water on either side of the wall may be at any elevation.

    b. When seepage effects are included, the following must be observed.

          b(1)   Water elevation on right side must be above water elevation on left side.

          b(2)   Seepage is assumed to commence on the right side at the lower of WATELR and SURELR(1).

          b(3)   Seepage is assumed to cease on the left side at the lower of WATELL and SURELL(1).

          b(4)   The value of seepage gradient provided as input must be positive, less than one; and must not result in zero net water pressure above the point at which seepage ceases on the left side.

11. Vertical Surcharge Loads on Rightside Surface (see Figure A4)

    a. Load units are assumed to be pounds per lineal foot (PLF) for line loads and pounds per square foot (PSF) for distributed loads.

    b. Zero (0) to four (4) line loads may be applied at any point on the rightside surface.

    c. Zero (0) or one (1) distributed surcharge load may be applied as shown in Figures A4b, A4c, A4d, and A4e.

          c(1)   A uniform distributed load (Figure A4b) may only be applied to a horizontal surface.

          c(2)   Distributed strip and triangular loads must be applied to a horizontal segment of the rightside surface.

          c(3)   A ramp load may be applied only on a horizontal surface or on the extension of a final horizontal segment of an irregular surface.

          c(4)   A rightside surface point may not lie within the limits of a distributed load.

12. Horizontal Line Loads (see Figure A5a)

    a. Load units are assumed to be pounds per lineal foot (PLF).

    b. Zero (0) to four (4) horizontal line loads may be applied anywhere at or below the top of the wall.

    c. Positive horizontal loads act to the left.
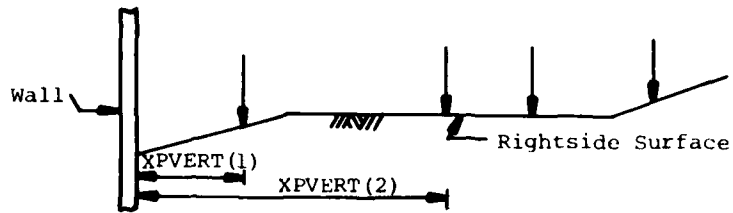
(a) Vertical Line Loads
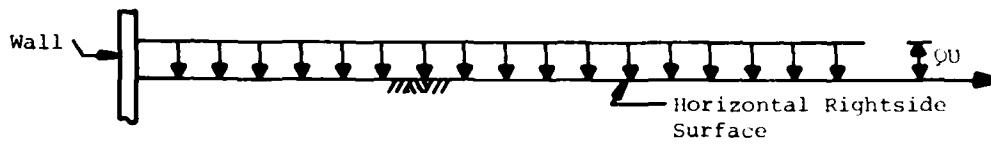
(b) Uniform Load
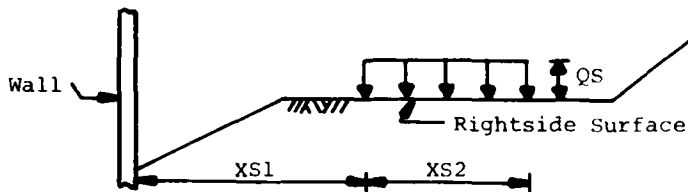
(c) Strip Load
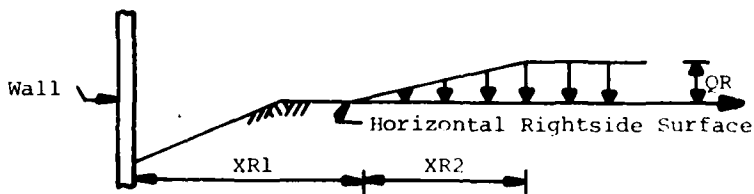
(d) Ramp Load
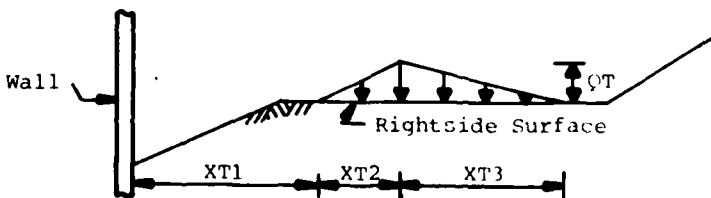
(e) Triangular Load

Figure A4. Data names for surcharge loads
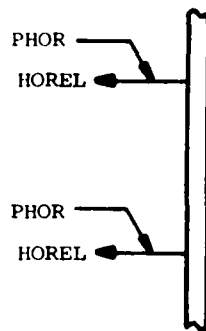
(a) Horizontal Line Loads
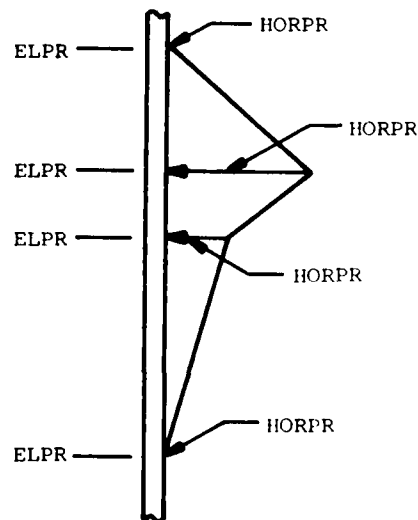
(b) Horizontal Distributed Load

Figure A5. Horizontal applied loads

13. Horizontal Applied Pressure Distribution (see Figure A5b)

    a. A general applied pressure distribution is assumed to be
       described by pairs of values giving the elevation and

magnitude of pressure for up to twelve points. The distribution is assumed to be linear between adjacent points.

    b. Points must be supplied in sequential order with elevations progressing downward.

    c. Dual pressure values at a single elevation are not permitted.

    d. The elevation of the first point must be at or below the top of the wall.

    e. All pressure values must have the same sign (either positive or negative).

    f. At least two points are required to describe a distribution.

    g. Pressure units are assumed to be pounds per square foot (PSF).

14. Input Data

    a. Input data may be entered during execution from the user's terminal or may be stored in a permanent file before the program is executed. The file name must be one (1) to six (6) alphanumeric characters beginning with an alphabetic character.

    b. Data are read in free field format.

        b(1) Data items on lines designated (alphanumeric) must be separated by one or more blanks.

        b(2) Data items on lines designated (numeric) may be separated by commas.

        b(3) Integer number values must be of form NNNN.

        b(4) Real number values may be of form XXXX, XX.XX, X.XXE+ee.

    c. Each line in a data file must begin with a nonzero integer line number denoted LN below. Line numbers are not required when data are entered during execution from the user's terminal.

    d. Input data lines must be in the sequence described below. Line descriptors enclosed in brackets [ ] or braces { } may not be required.

    e. Lower case words enclosed by single quotes, in the description below indicate alphanumeric information.

    f. All alphanumeric keywords may be abbreviated with the underlined character(s).

15. Input Data Sequence and Description

    a. Header--One (1) to four (4) lines are provided for identifying the run.

        a(1) Header Line 1 (alphanumeric)

            (a) Contents

                [LN] NLINES 'heading'

(b) Definitions

      [LN] = line number (not required if data
                   entered during execution from user's
                   terminal)

    NLINES = total number of header lines = integer
                1 to 4

  'header' = any alphanumeric information

(c) **Total characters on Header Line 1 including LN,
NLINES, 'heading,' and embedded blanks must be
≤ 80. Blank 'heading' is not permitted.**

<u>a</u>(2) Header Lines 2 to NLINES ([data] not required if
NLINES = 1) (alphanumeric)

  (a) Contents

    [LN]['heading']

  (b) Total characters including LN, 'heading,' and em-
bedded blanks must be ≤ 80. Blank 'heading' is
not permitted.

<u>b</u>. Wall Type, Mode, Method--One (1) Line (alphanumeric)

<u>b</u>(1) Contents

  [LN] 'type' 'mode' [nmethods] ['methods']

<u>b</u>(2) Definitions

  'type' = <u>C</u>ANTILEVER or <u>A</u>NCHORED

  'mode' = <u>A</u>NALYSIS or <u>D</u>ESIGN

  [nmethods] (not required if 'type' = <u>C</u>ANTILEVER)
       = integer 1 to 5 indicating the number of
       methods described below to be used in
       <u>A</u>NALYSIS or <u>D</u>ESIGN of an anchored wall

  ['methods'] (not required if 'type' = <u>C</u>ANTILEVER)
       1 to 5 of the following codes

     = <u>FR</u> for Free Earth Method
     = <u>FI</u> for Fixed Earth Method
     = <u>EB</u> for Equivalent Beam Method
     = <u>EM</u> for Equal Moment Method
     = <u>TE</u> for Terzaghi Method

<u>c</u>. Wall Description--One (1) Line (numeric)

<u>c</u>(1) Contents if 'type' = <u>C</u>ANTILEVER and 'mode' = <u>D</u>ESIGN

  [LN] TOPEL FS

<u>c</u>(2) Contents if 'type' = <u>C</u>ANTILEVER and 'mode' = <u>A</u>NALYSIS

  [LN] TOPEL BOTEL EMOD SECMOM

<u>c</u>(3) Contents if 'type' = <u>A</u>NCHORED and 'mode' = <u>D</u>ESIGN

  [LN] TOPEL ANCHEL FS

c(4) Contents if 'type' = ANCHORED and 'mode' = ANALYSIS

[LN] TOPEL ANCHEL BOTEL EMOD SECMOM

c(5) Definitions

TOPEL = elevation of top of wall (FT)

ANCHEL = elevation of anchor (FT)

BOTEL = elevation of bottom of wall (FT)

FS = factor of safety

EMOD = modulus of elasticity (PSI)

SECMOM = moment of inertia (IN^4)

d. Rightside Soil Description--Three (3) to twenty-two (22) lines

d(1) Control--One (1) line (numeric)

(a) Contents

[LN] NSURRT NLAYRT

(b) Definitions

NSURRT = number of rightside surface points (1 to 15)

NLAYRT = number of rightside soil layers (1 to 15)

d(2) Rightside Surface Point Coordinates--({data} not required if NSURRT = 1) (numeric)

(a) Surface Point Elevations, NSURRT Values, five (5) per line

[LN] SURELR(1) {SURELR(2)...SURELR(NSURRT)}

(b) Surface Point X-Coordinates, NSURRT-1 Values, five (5) per line, omit entire line if NSURRT = 1

[LN] {XSURRT(2)...XSURRT(NSURRT)}

(c) Definitions

SURELR(I) = elevation of Ith surface point (FT)

XSURRT(I) = distance from wall to Ith surface point (FT)

Point numbers start with 1 at wall and proceed in sequence away from wall

d(3) Rightside Soil Layer Data--NLAYRT lines (numeric) ({data} not required for I = NLAYRT) (Layer 1 is surface layer, layers proceed sequentially downward)

(a) Contents

[LN] GAMRT(I) PHIRT(I) CRT(I) DELTRT(I) {ELLAYR(I), SLOPER(I)}

A12

(b) Definitions

    GAMRT(I) = unsubmerged unit weight (PCF)

    PHIRT(I) = angle of internal friction (DEG)

      CRT(I) = cohesion (PSF)

    DELTRT(I) = angle of wall friction (DEG)

    ELLAYR(I) = elevation at wall of boundary be-
             tween layer I and layer I + 1 (FT)

    SLOPER(I) = slope of boundary between layer I
             and layer I + 1 (FT) (interpreted as
             rise per foot, positive if boundary
             slopes up away from wall)

e. Leftside Soil Description--Three (3) to twenty-two (22)
lines

  e(1) Control--One (1) line (numeric)

    (a) Contents

      [LN] NSURLT NLAYLT

    (b) Definitions

      NSURLT = number of leftside surface points (1
             to 15)

      NLAYLT = number of leftside soil layers (1 to
             15)

  e(2) Leftside Surface Point Coordinates--({data} not re-
quired if NSURLT = 1) (numeric)

    (a) Surface Point Elevations, NSURLT Values, five (5)
per line

      [LN] SURELL(1) {SURELL(2)...SURELL(NSURLT)}

    (b) Surface Point X-Coordinates, NSURLT-1 Values,
five (5) per line, omit entire line if NSURLT
= 1

      [LN] {XSURLT(2)...XSURLT(NSURLT)}

    (c) Definitions

      SURELL(I) = elevation of Ith surface point (FT)

      XSURLT(I) = distance from wall to Ith surface
             (FT)

      Point numbers start with 1 at wall and proceed
in sequence away from wall

  e(3) Leftside Soil Layer Data--NLAYLT lines
({data} not required for I = NLAYLT)

    (a) Contents

      [LN] GAMLT(I) PHILT(I) CLT(I) DELTLT(I)
      {ELLAYL(I), SLOPEL(I)}

A13

(b) Definitions

GAMLT(I) = unsubmerged unit weight (PCF)

PHILT(I) = angle of internal friction (DEG)

CLT(I) = cohesion (PSF)

DELTLT(I) = angle of wall friction (DEG)

ELLAYL(I) = elevation at wall of boundary be-
tween layer I and layer I + 1 (FT)

SLOPEL(I) = slope of boundary between layer I
and layer I + 1 (FT) (interpreted
as rise per foot, positive if bound-
ary slopes up away from wall)

f. Water Data--One (1) line (numeric)

f(1) Contents

[LN] WATELR WATELL GAMWAT SEEP

f(2) Definitions

WATELR = water elevation on rightside (FT)

WATELL = water elevation on left side (FT)

GAMWAT = unit weight of water (PCF) (If GAMWAT input
as zero, default to GAMWAT = 62.4. If
GAMWAT input as negative, water effects are
not considered)

SEEP = seepage gradient FT/FT)

g. Vertical Loads on Rightside--One (1) to three (3) lines
(alphanumeric)

g(1) Control--One (1) line

(a) Contents

[LN] NPVERT 'distributed load'

(b) Definitions

NPVERT = number of vertical concentrated loads
(0 to 4)

'distributed load' = NONE if no distributed load
= UNIFORM for uniform load
= STRIP for strip load
= RAMP for ramp load
= TRIANGULAR for triangular
load

A14

g(2) Vertical Line Loads--Zero (0) or one (1) line
      ([data] not required if NPVERT = 0)

(a) Contents

     [LN] [XPVERT(I) PVERT(I)...XPVERT(NPVERT)
     PVERT(NPVERT)]

(b) Definitions

     XPVERT(I) = distance of Ith load from wall (FT)

      PVERT(I) = magnitude of Ith load (PLF)

g(3) Distributed Vertical Load--Zero (0) or one (1) line
      (numeric)
      ([data] not required if 'distributed load' = NONE)
      ({data} not required if 'distributed load' ≠
      TRIANGULAR)

(a) Contents

     [LN] [X1 X2 {X3} Q]

(b) Definitions

     X1 = distance from wall to start of STRIP,
          RAMP, or TRIANGULAR load (FT)

     X2 = width of STRIP distribution (FT)
        = width of increasing load for RAMP or
          TRIANGULAR (FT)

     X3 = width of decreasing load for TRIANGULAR
          (FT)

      Q = magnitude of maximum distributed load
          (PSF)

     Only LN and Q are required for UNIFORM distri-
     buted load

h. Horizontal Loads--One (1) to five (5) lines (numeric)

h(1) Control--One (1) line

(a) Contents

     [LN] NPHOR NHORPR EQACC

(b) Definitions

     NPHOR = number of horizontal line loads (0 to 4)

     NHORPR = number of points for horizontal distri-
              bution = integers 0 or 2 to 12

     EQACC = earthquake acceleration (G's), positive
             number, 0.0 ≤ EQACC < 1.0

h(2) Horizontal Line Loads--Zero (0) or one (1) line
      ([data] not required if NPHOR = 0) (numeric)

(a) Contents

     [LN] [HOREL(1) PHOR(1)...HOREL(NPHOR)
     PHOR(NPHOR)]

A15

(b) Definitions

   HOREL(I) = elevation of Ith load (FT)

   PHOR(I) = magnitude of Ith load (PLF)

<u>h</u>(3) Horizontal Pressure Distribution--Zero (0) to three (3) lines
([data] not required if NHORPR = 0) (numeric)
NHORPR pairs of values, four (4) pairs per line

(a) Contents

   [LN] [ELPR(1)   HORPR(1)...ELPR(NHORPR)
   HORPR(NHORPR)]

(b) Definitions

   ELPR(I) = elevation of Ith pressure point (FT)

   HORPR(I) = horizontal pressure at ELPR(I) (PSF)

   Point numbers start at top point and proceed
   sequentially downward

Abbreviated Input Guide

16. Notation

<u>a</u>. Data items enclosed in brackets [ ] may not be required

<u>b</u>. Data items enclosed in braces { } indicate choose one (or more)

17. Input

<u>a</u>. Header--One (1) to four (4) lines

   LN   NLINES   'heading'

   [LN   'heading']

   [LN   'heading']

   [LN   'heading']

<u>b</u>. Wall Type, Mode, Method--One (1) line

$$[LN] \begin{Bmatrix} \underline{CANTILEVER} \\ \underline{ANCHORED} \end{Bmatrix} \begin{Bmatrix} \underline{DESIGN} \\ \underline{ANALYSIS} \end{Bmatrix} [NMETH] \begin{bmatrix} \underline{FR} \\ \underline{FI} \\ \underline{EB} \\ \underline{EM} \\ \underline{TE} \end{bmatrix}$$

<u>c</u>. Wall Description--One (1) line

   LN   TOPEL   {ANCHEL} {BOTEL} {EMOD} {SECMOM} {FS}

A16

d. Rightside Soil Description—Three (3) to twenty-two (22) lines

   d(1) Control—One (1) line

       LN NSURRT NLAYRT

   d(2) Rightside Surface Point Coordinates—One (1) to six (6) lines

       LN SURELR(1) [SURELR(2)...SURELR(NSURRT)]
       [LN XSURRT(2)...XSURRT(NSURRT)]

   d(3) Rightside Soil Layer Data—One (1) to fifteen (15) lines

       LN GAMRT(I) PHIRT(I) CRT(I) DELTRT(I) [ELLAYR(I)
       SLOPER(I)]

e. Leftside Soil Description—Three (3) to twenty-two (22) lines

   e(1) Control—One (1) line

       LN NSURLT NLAYLT

   e(2) Leftside Surface Point Coordinates—One (1) to six (6) lines

       LN SURELL(1) [SURELL(2)...SURELL(NSURLT)]
       [LN XSURLT(2)...XSURLT(NSURLT)]

   e(3) Leftside Soil Layer Data—One (1) to fifteen (15) lines

       LN GAMLT(I) PHILT(I) CL(I) DELTLT(I) [ELLAYL(I)
       SLOPEL(I)]

f. Water Data—One (1) line

       LN WATELR WATELL GAMWAT SEEP

g. Vertical Loads on Rightside—One (1) to three (3) lines

   g(1) Control—One (1) line

$$\text{LN}\quad \text{NPVERT} \begin{cases} \underline{\text{NONE}} \\ \underline{\text{UNIFORM}} \\ \underline{\text{STRIP}} \\ \underline{\text{RAMP}} \\ \underline{\text{TRIANGULAR}} \end{cases}$$

   g(2) Vertical Line Loads—Zero (0) or one (1) line

       [LN XPVERT(1) PVERT(1)...XPVERT(NPVERT)
       PVERT(NPVERT)]

   g(3) Distributed Vertical Load—Zero (0) or one (1) line

       [LN {X1} {X2} {X3} Q]

h. Horizontal Loads--One (1) or two (2) lines

    h(1)   Control--One (1) line

        LN NPHOR NHORPR EQACC

    h(2)   Horizontal Line Loads--Zero (0) or one (1) line

        [LN HOREL(1) PHOR(1)...HOREL(NPHOR) PHOR(NPHOR)]

    h(3)   Horizontal Pressure Distribution--Zero (0) to three (3) lines

        [LN ELPR(1) HORPR(1)...ELPR(NHORPR) HORPR(NHORPR)]

Appendix B: Problem "ANCH1"--Design
Of an Anchored Wall on Granular Soil
With Uniform Surcharge

1.   The anchored wall shown in Figure B1a was designed by all five
methods incorporated in the program.   Input data were read from the file
listed on page B5.   An ehco of input data is shown on pages B6 and B7.
Results are shown on pages B8-B19 along with program prompts to deter-
mine the type of data desired by the user.   Results are plotted in
Figures B1b-B1d.

2.   A solution for design penetration of this wall by the free
earth method is presented in Foundation Analysis and Design.*   Hand cal-
culations for design penetration, maximum bending moment, and anchor
force for the free earth, equivalent beam, and equal moment methods are
included on pages B20-B26.   Differences between hand-calculated values
and program results are attributable to truncation of the numerical
values in the hand calculations.

---

*   Bowles, Joseph E.   1977.   Foundation Analysis and Design, 2nd ed.,
    McGraw-Hill, New York.

Figure B1. System and program results for problem "ANCH1" (sheet 1 of 3)
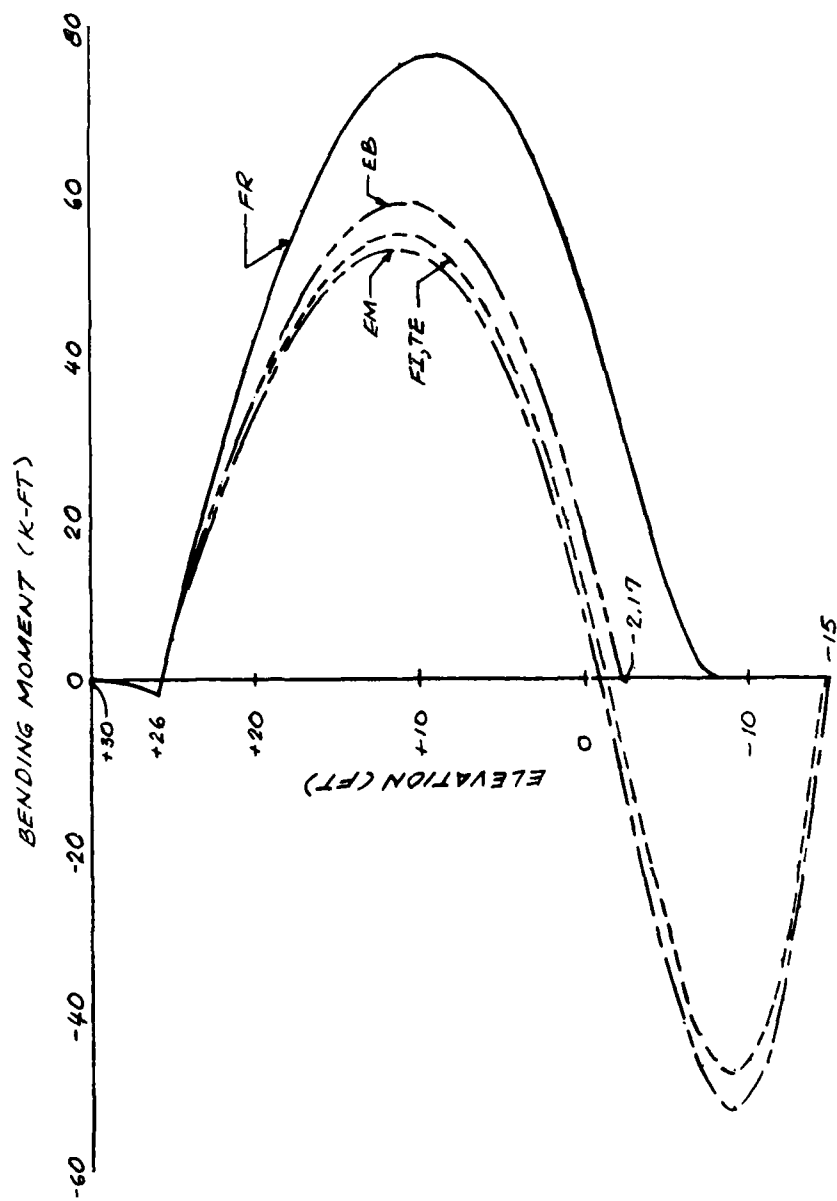
c. BENDING MOMENT

Figure Bl. (sheet 2 of 3)

B3
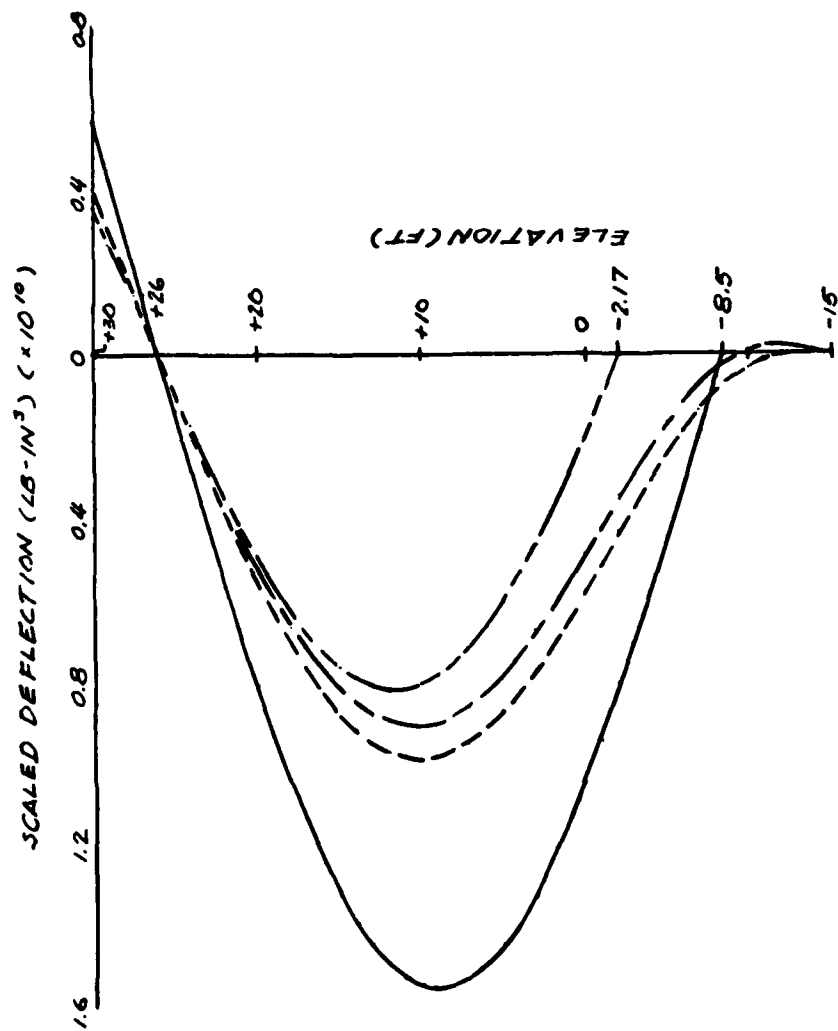
d. SCALED DEFLECTION

Figure B1.   (sheet 3 of 3)

B4

```
1000 3 PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
1010 FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
1020 EXAMPLE 13-3, PP 29-431
1030 A D 5 FR FI EB EM TE
1040 30 26 1
1050 1 2
1060 30
1070 105 30 0 20 22 0
1080 128.5 30 0 20
1090 1 1
1100 0
1110 128.5 30 0 20
1120 22 22 62.5 1
1130 0 U
1140 500
1150 0 0 0
```

PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 01/21/81   TIME: 10:47:16

1. INPUT DATA

1.A.--HEADING

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 29-431

1.B.--WALL TYPE, MODE, METHOD
     ANCHORED WALL DESIGN   BY FREE EARTH METHOD
     ANCHORED WALL DESIGN   BY FIXED EARTH METHOD
     ANCHORED WALL DESIGN   BY EQUIVALENT BEAM METHOD
     ANCHORED WALL DESIGN   BY EQUAL MOMENT METHOD
     ANCHORED WALL DESIGN   BY TERZAGHI METHOD

1.C.--WALL DESCRIPTION
     TOP OF WALL ELEVATION =   30.00 (FT)
     ANCHOR ELEVATION   =   26.00 (FT)
     FACTOR OF SAFETY   =   1.00

1.D.--RIGHT SIDE SOIL DESCRIPTION
     NUMBER OF RIGHT SIDE SURFACE POINTS = 1
     NUMBER OF RIGHT SIDE SOIL LAYERS   = 2

     RIGHT SIDE SURFACE POINT COORDINATES
     POINT   ELEVATION   X-COORD
     NO.   (FT)   (FT)
      1   30.00   0.00

RIGHT SIDE SOIL LAYER DATA
                   INTERNAL   WALL   BOTTOM
LAYER   UNIT   FRICTION   FRICTION   ELEV   BOTTOM
NO.   WEIGHT   ANGLE   COHESION   ANGLE   AT WALL   SLOPE
         (PCF)   (DEG)   (PSF)   (DEG)   (FT)   (FT/FT)
  1   105.00   30.00   0.00   20.00   22.00   1:0.0
  2   128.50   30.00   0.00   20.00

B6

```
1.E.--LEFT SIDE SOIL DESCRIPTION
     NUMBER OF LEFT SIDE SURFACE POINTS    =  1
     NUMBER OF LEFT SIDE SOIL LAYERS       =  1


     LEFT SIDE SURFACE POINT COORDINATES
     POINT      ELEVATION      X-COORD
      NO.         (FT)          (FT)
       1          0.00          0.00


LEFT  SIDE SOIL LAYER DATA
                    INTERNAL              WALL     BOTTOM
LAYER    UNIT     FRICTION             FRICTION    ELEV      BOTTOM
 NO.    WEIGHT     ANGLE    COHESION    ANGLE    AT WALL     SLOPE
        (PCF)      (DEG)     (PSF)      (DEG)      (FT)     (FT/FT)
  1     128.50     30.00      0.00      20.00


1.F.--WATER DATA
     RIGHT SIDE ELEVATION          =   22.00 (FT)
     LEFT SIDE ELEVATION           =   22.00 (FT)
     WATER UNIT WEIGHT             =   62.50 (PCF)
     PRESSURE REDUCTION OPTION     =    1


1.G.--SURCHARGE LOADS
     NUMBER OF LINE LOADS          =  0
     DISTRIBUTED LOAD DISTRIBUTION = UNIF


     UNIFORM SURCHARGE LOAD
     LOAD              =  500.00 PSF


1.H.--HORIZONTAL LOADS
     NUMBER OF HORIZONTAL LINE LOADS        =    0
     NUMBER OF HORIZONTAL PRESSURE POINTS   =    0
     EARTHQUAKE ACCELERATION                =    0.00 (G'S)
```

PROGRAM SHTWAL - DESIGN/ANALYSIS OF ANCHORED
OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS
DATE: 01/21/81   TIME: 11:00:07

2. RESULTS

2.A.--HEADING

PROBLEM - ANCH1 - ANCHORED WALL DESIGN - GRANULAR SOIL
FROM 'FOUNDATION ANALYSIS AND DESIGN' BY J. E. BOWLES
EXAMPLE 13-3, PP 29-431

2.B.--SUMMARY OF RESULTS FOR ANCHORED   WALL DESIGN

        SOIL PRESSURES DETERMINED BY COULOMB
        COEFFICIENTS AND THEORY OF ELASTICITY
        EQUATIONS FOR SURCHARGE LOADS

	WALL BOTTOM		MAXIMUM	MAX SCALED	ANCHOR
METHOD	PEN	ELEV	BENDING MOMENT	DEFLECTION	FORCE
	(FT)	(FT)	(LB-FT)	(LB-IN3)	(LB)
FREE EARTH :	8.5	-8.5	76537.	1.56E+10	9015.
FIXED EARTH:	15.0	-15.0	54551.	9.96E+09	7632.
EQUIV BEAM :	13.8	-13.8	58348.	8.24E+09	7885.
EQUAL MOM :	14.6	-14.6	52690.	9.15E+09	7506.
TERZAGHI :	14.4	-14.4	54512.	9.95E+09	7630.

        (NOTE: PENETRATION FOR EQUIVALENT BEAM
        METHOD DOES NOT INCLUDE INCREASE
        PRESCRIBED BY DRAFT EM 1110-2-2906)

        (NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
        OF ELASTICITY IN PSI TIMES PILE MOMENT OF
        INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

```
        DO YOU WANT COMPLETE RESULTS OUTPUT?
         ENTER 'YES' OR 'NO'
I>Y




        COMPLETE RESULTS ARE AVAILABLE FOR FOLLOWING
        METHODS OF ANALYSIS:
             FREE EARTH : ENTER 'FR' ON CUE
             FIXED EARTH: ENTER 'FI' ON CUE
             EQUIV BEAM : ENTER 'EB' ON CUE
             EQUAL MOM  : ENTER 'EM' ON CUE
             TERZAGHI   : ENTER 'TE' ON CUE




        ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>FR
```

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN BY FREE EARTH METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	0.	0.	-5.76E+09	148.66
29.00	-80.	-164.	-4.32E+09	179.87
28.00	-339.	-360.	-2.88E+09	211.09
27.00	-809.	-586.	-1.44E+09	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	8171.	0.	273.53
25.00	6506.	7881.	1.44E+09	304.75
24.00	14230.	7561.	2.87E+09	335.96
23.00	21618.	7210.	4.28E+09	367.18
22.00	28639.	6827.	5.65E+09	398.40
21.00	35263.	6419.	6.97E+09	418.02
20.00	41470.	5991.	8.23E+09	437.65
19.00	47238.	5543.	9.42E+09	457.27
18.00	52550.	5076.	1.05E+10	476.89
17.00	57384.	4589.	1.15E+10	496.51
16.00	61722.	4083.	1.25E+10	516.14
15.00	65544.	3557.	1.33E+10	535.76
14.00	68830.	3012.	1.40E+10	555.38
13.00	71561.	2446.	1.45E+10	575.01
12.00	73716.	1862.	1.50E+10	594.63
11.00	75277.	1257.	1.53E+10	614.25
10.00	76224.	633.	1.55E+10	633.87
9.00	76537.	-11.	1.56E+10	653.50
8.00	76197.	-674.	1.55E+10	673.12
7.00	75183.	-1357.	1.53E+10	692.74
6.00	73476.	-2059.	1.50E+10	712.36
5.00	71058.	-2782.	1.45E+10	731.99
4.00	67907.	-3523.	1.40E+10	751.61
3.00	64004.	-4285.	1.33E+10	771.23
2.00	59331.	-5066.	1.24E+10	790.85
1.00	53866.	-5866.	1.15E+10	810.48
0.00	47591.	-6687.	1.05E+10	830.10

```
-1.00      40553.     -7325.     9.46E+09       446.77
-2.17      31814.     -7586.     8.11E+09         0.00
-3.00      25521.     -7452.     7.09E+09      -319.89
-4.00      18293.     -6940.     5.84E+09      -703.22
-5.00      11768.     -6046.     4.55E+09     -1086.55
-6.00       6329.     -4767.     3.24E+09     -1469.88
-7.00       2361.     -3106.     1.93E+09     -1853.22
-8.00        245.     -1061.     6.04E+08     -2236.55
-8.46          0.       -0.         0.        -2411.54
```

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>Y

ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED

2.C.--COMPLETE RESULTS FOR ANCHORED   WALL DESIGN
     BY FIXED EARTH METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	0.	0.	-3.97E+09	148.66
29.00	-80.	-164.	-2.98E+09	179.87
28.00	-339.	-360.	-1.99E+09	211.09
27.00	-809.	-586.	-9.93E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	6788.	0.	273.53
25.00	5124.	6499.	9.94E+08	304.75
24.00	11465.	6179.	1.98E+09	335.96
23.00	17470.	5827.	2.94E+09	367.18
22.00	23109.	5444.	3.88E+09	398.40
21.00	28350.	5036.	4.77E+09	418.02
20.00	33174.	4608.	5.62E+09	437.65
19.00	37560.	4161.	6.41E+09	457.27
18.00	41489.	3694.	7.13E+09	476.89
17.00	44940.	3207.	7.79E+09	496.51
16.00	47896.	2701.	8.36E+09	516.14
15.00	50335.	2175.	8.85E+09	535.76
14.00	52238.	1629.	9.26E+09	555.38
13.00	53586.	1064.	9.57E+09	575.01
12.00	54359.	479.	9.80E+09	594.63
11.20	54551.	0.	9.90E+09	610.23
11.00	54538.	-125.	9.93E+09	614.25
10.00	54102.	-749.	9.96E+09	633.87
9.00	53032.	-1393.	9.90E+09	653.50
8.00	51309.	-2056.	9.75E+09	673.12
7.00	48913.	-2739.	9.51E+09	692.74
6.00	45824.	-3442.	9.19E+09	712.36
5.00	42022.	-4164.	8.79E+09	731.99
4.00	37489.	-4906.	8.31E+09	751.61
3.00	32204.	-5667.	7.77E+09	771.23
2.00	26148.	-6448.	7.18E+09	790.85
1.00	19301.	-7249.	6.54E+09	810.48
0.00	11643.	-8069.	5.86E+09	830.10
-1.00	3222.	-8708.	5.17E+09	446.77

```
   -2.17        -7129.       -8968.      4.36E+09          0.00
   -3.00       -14576.       -8835.      3.78E+09       -319.89
   -4.00       -23186.       -8323.      3.12E+09       -703.22
   -5.00       -31094.       -7428.      2.49E+09      -1086.55
   -6.00       -37915.       -6150.      1.92E+09      -1469.88
   -7.00       -43266.       -4488.      1.42E+09      -1853.22
   -8.00       -46764.       -2444.      9.88E+08      -2236.55
   -9.00       -48026.         -15.      6.38E+08      -2619.88
  -10.00       -46667.        2796.      3.71E+08      -3003.21
  -11.00       -42306.        5991.      1.83E+08      -3386.54
  -12.00       -34557.        9569.      6.85E+07      -3769.87
  -13.00       -23039.       13531.      1.30E+07      -4153.20
  -13.35       -18088.       14996.      4.09E+06      -4286.31
  -13.60       -14144.       15546.      0.                0.00
  -14.97           0.           0.     -4.55E+06      22784.10
```

         (NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
         OF ELASTICITY IN PSI TIMES PILE MOMENT OF
         INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

      DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
 I>Y
      ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
 I>EB

2.C.--COMPLETE RESULTS FOR ANCHORED   WALL DESIGN
     BY EQUIV BEAM   METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	-0.	0.	-3.58E+09	148.66
29.00	-80.	-164.	-2.69E+09	179.87
28.00	-339.	-360.	-1.79E+09	211.09
27.00	-809.	-586.	-8.96E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	7041.	0.	273.53
25.00	5377.	6752.	8.97E+08	304.75
24.00	11971.	6432.	1.78E+09	335.96
23.00	18230.	6080.	2.65E+09	367.18
22.00	24121.	5697.	3.49E+09	398.40
21.00	29616.	5289.	4.28E+09	418.02
20.00	34692.	4861.	5.02E+09	437.65
19.00	39332.	4414.	5.71E+09	457.27
18.00	43513.	3947.	6.32E+09	476.89
17.00	47218.	3460.	6.86E+09	496.51
16.00	50427.	2954.	7.32E+09	516.14
15.00	53119.	2428.	7.69E+09	535.76
14.00	55276.	1882.	7.97E+09	555.38
13.00	56877.	1317.	8.15E+09	575.01
12.00	57903.	732.	8.24E+09	594.63
11.00	58334.	128.	8.23E+09	614.25
10.79	58348.	0.	8.20E+09	618.32
10.00	58152.	-496.	8.11E+09	633.87
9.00	57335.	-1140.	7.90E+09	653.50

```
    8.00      55865.      -1803.      7.58E+09      673.12
    7.00      53722.      -2486.      7.17E+09      692.74
    6.00      50886.      -3189.      6.67E+09      712.36
    5.00      47337.      -3911.      6.08E+09      731.99
    4.00      43057.      -4653.      5.41E+09      751.61
    3.00      38025.      -5414.      4.66E+09      771.23
    2.00      32222.      -6195.      3.85E+09      790.85
    1.00      25628.      -6996.      2.98E+09      810.48
    0.00      18224.      -7816.      2.06E+09      830.10
   -1.00      10056.      -8455.      1.12E+09      446.77
   -2.17          0.      -8715.      0.              0.00
```

             (NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
             OF ELASTICITY IN PSI TIMES PILE MOMENT OF
             INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

             (NOTE: OUTPUT TABLE FOR EQUIVALENT BEAM
             METHOD ENDS AT ASSUMED POINT OF INFLECTION)

      DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'

I>Y
     ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>EM

2.C.--COMPLETE RESULTS FOR ANCHORED WALL DESIGN BY EQUAL MOM METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	-0.	0.	-3.73E+09	148.66
29.00	-80.	-164.	-2.80E+09	179.87
28.00	-339.	-360.	-1.86E+09	211.09
27.00	-809.	-586.	-9.33E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	6661.	0.	273.53
25.00	4997.	6372.	9.34E+08	304.75
24.00	11212.	6052.	1.86E+09	335.96
23.00	17090.	5700.	2.76E+09	367.18
22.00	22602.	5317.	3.64E+09	398.40
21.00	27717.	4909.	4.48E+09	418.02
20.00	32414.	4481.	5.27E+09	437.65
19.00	36673.	4034.	6.00E+09	457.27
18.00	40475.	3567.	6.67E+09	476.89
17.00	43801.	3080.	7.27E+09	496.51
16.00	46629.	2574.	7.80E+09	516.14
15.00	48942.	2048.	8.24E+09	535.76
14.00	50718.	1502.	8.60E+09	555.38
13.00	51940.	937.	8.87E+09	575.01
12.00	52586.	352.	9.05E+09	594.63
11.41	52690.	0.	9.11E+09	606.14
11.00	52638.	-252.	9.15E+09	614.25
10.00	52076.	-876.	9.15E+09	633.87
9.00	50879.	-1520.	9.06E+09	653.50
8.00	49029.	-2183.	8.88E+09	673.12
7.00	46506.	-2866.	8.62E+09	692.74
6.00	43291.	-3569.	8.28E+09	712.36
5.00	39363.	-4291.	7.86E+09	731.99
4.00	34702.	-5033.	7.38E+09	751.61
3.00	29291.	-5794.	6.83E+09	771.23
2.00	23108.	-6575.	6.24E+09	790.85
1.00	16134.	-7376.	5.60E+09	810.48
0.00	8350.	-8196.	4.94E+09	830.10

```
 -1.00        -197.      -8834.      4.26E+09)      446.77
 -2.17      -10696.      -9095.      3.48E+09         0.00
 -3.00      -18249.      -8961.      2.93E+09      -319.89
 -4.00      -26986.      -8450.      2.30E+09      -703.22
 -5.00      -35020.      -7555.      1.72E+09     -1086.55
 -6.00      -41968.      -6277.      1.20E+09     -1469.88
 -7.00      -47446.      -4615.      7.45E+08     -1853.22
 -8.00      -51071.      -2570.      3.77E+08     -2236.55
 -9.00      -52459.       -142.      9.75E+07     -2619.88
-10.00      -51227.       2670.     -9.23E+07     -3003.21
-11.00      -46992.       5864.     -1.94E+08     -3386.54
-12.00      -39370.       9443.     -2.15E+08     -3769.87
-13.00      -27979.      13404.     -1.68E+08     -4153.20
-14.00      -12434.      17749.     -7.40E+07     -4536.53
-14.65          0.      20761.         0.         -4784.25
```

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

```
    DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>Y
    ENTER METHOD FOR WHICH COMPLETE RESULTS ARE DESIRED
I>TE
```

## 2.C.—COMPLETE RESULTS FOR ANCHORED WALL DESIGN BY TERZAGHI METHOD

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN3)	NET PRESSURE (PSF)
30.00	-0.	0.	-3.96E+09	148.66
29.00	-80.	-164.	-2.97E+09	179.87
28.00	-339.	-360.	-1.98E+09	211.09
27.00	-809.	-586.	-9.92E+08	242.31
26.00	-1522.	-844.	0.	273.53
26.00	-1522.	6785.	0.	273.53
25.00	5121.	6496.	9.93E+08	304.75
24.00	11460.	6176.	1.98E+09	335.96
23.00	17463.	5824.	2.94E+09	367.18
22.00	23098.	5442.	3.87E+09	398.40
21.00	28337.	5033.	4.77E+09	418.02
20.00	33158.	4605.	5.61E+09	437.65
19.00	37541.	4158.	6.40E+09	457.27
18.00	41468.	3691.	7.13E+09	476.89
17.00	44917.	3204.	7.78E+09	496.51
16.00	47869.	2698.	8.35E+09	516.14
15.00	50306.	2172.	8.84E+09	535.76
14.00	52207.	1626.	9.25E+09	555.38
13.00	53552.	1061.	9.56E+09	575.01
12.00	54323.	476.	9.78E+09	594.63
11.21	54512.	0.	9.88E+09	610.15
11.00	54498.	-128.	9.91E+09	614.25
10.00	54060.	-752.	9.95E+09	633.87
9.00	52988.	-1396.	9.89E+09	653.50
8.00	51262.	-2059.	9.74E+09	673.12
7.00	48863.	-2742.	9.50E+09	692.74
6.00	45771.	-3445.	9.17E+09	712.36
5.00	41967.	-4167.	8.77E+09	731.99
4.00	37431.	-4909.	8.30E+09	751.61
3.00	32143.	-5670.	7.76E+09	771.23
2.00	26084.	-6451.	7.16E+09	790.85
1.00	19235.	-7252.	6.52E+09	810.48
0.00	11575.	-8072.	5.85E+09	830.10

-1.00	3151.	-8710.	5.16E+09	446.77
-2.17	-7203.	-8971.	4.34E+09	0.00
-3.00	-14652.	-8837.	3.77E+09	-319.89
-4.00	-23265.	-8326.	3.11E+09	-703.22
-5.00	-31176.	-7431.	2.48E+09	-1086.55
-6.00	-37999.	-6153.	1.91E+09	-1469.88
-7.00	-43353.	-4491.	1.41E+09	-1853.22
-8.00	-46854.	-2446.	9.80E+08	-2236.55
-9.00	-48118.	-18.	6.31E+08	-2619.88
-10.00	-46762.	2794.	3.66E+08	-3003.21
-11.00	-42403.	5988.	1.80E+08	-3386.54
-12.00	-34657.	9567.	6.75E+07	-3769.87
-13.00	-23142.	13528.	1.42E+07	-4153.20
-14.00	-7473.	17873.	3.49E+05	-4536.53
-14.40	0.	19708.	0.	-4689.03

(NOTE: DIVIDE SCALED DEFLECTION BY MODULUS
OF ELASTICITY IN PSI TIMES PILE MOMENT OF
INERTIA IN IN**4 TO OBTAIN DEFLECTION IN INCHES)

DO YOU WANT RESULTS FOR ANOTHER METHOD? ENTER 'YES' OR 'NO'
I>N
DO YOU WANT GEOMETRY AND/OR RESULTS PLOTTED?
ENTER 'GEOMETRY', 'RESULTS', 'BOTH', OR 'NEITHER'
I>N
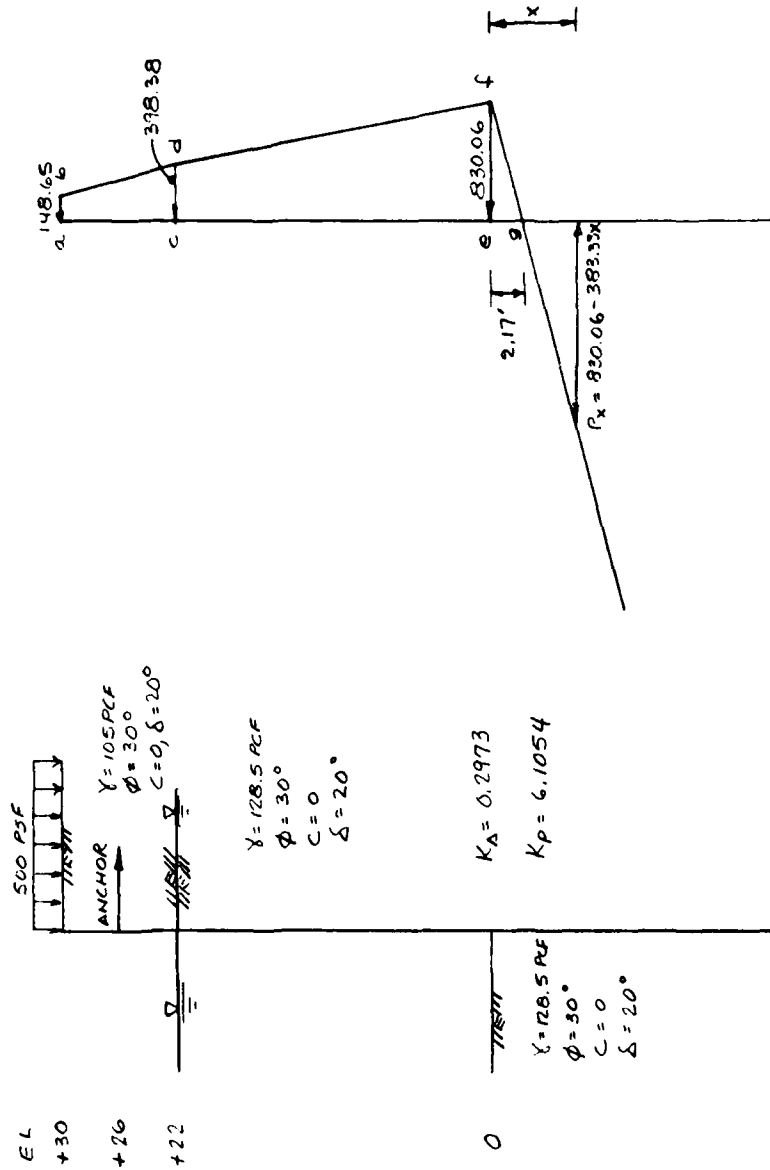
NET PRESSURES

SYSTEM ($FS=1$, $\gamma_W = 62.5 PCF$)

DESIGN BY FREE EARTH METHOD

830.06 - 383.33d
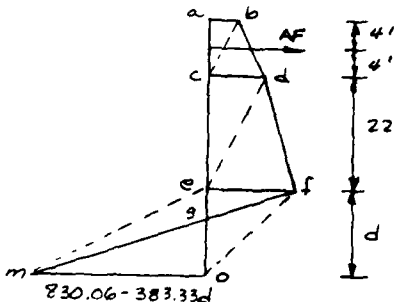
FORCE	PRESS DIAG	FACTORS	MOMENT ARM ABOUT AF	MOMENT ABOUT AF
P_1	abc	$(148.65)(8)/2 = 594.60$	$8/3 - 4 = -1.33$	-790.82
P_2	bcd	$(398.38)(8)/2 = 1573.52$	$16/3 - 4 = 1.33$	2092.78
P_3	cde	$(398.38)(22)/2 = 4382.18$	$22/3 + 4 = 11.33$	49650.10
P_4	def	$(830.06)(22)/2 = 9130.66$	$44/3 + 4 = 18.67$	170469.42
P_5	efo	$(830.06)d/2 = 415.03d$	$26 + 0.33d$	$10790.78d + 136.96d^2$
P_6	emo	$(830.06 - 383.33d)(d)/2$ $= 415.03d - 191.67d^2$	$26 + 0.67d$	$10790.78d$ $-4705.35d^2$ $-128.42d^3$

$$\Sigma F_H = 15680.96 + 830.06d - 191.67d^2 - AF$$

$$\Sigma M_{AF} = 221421.48 + 21581.56d - 4568.39d^2 - 128.42d^3$$

FOR $\Sigma M_{AF} = 0$:

TRIAL d	ΣM
8	35946
9	-48002

INTERPOLATE $d = 8 + 35946/(35946 + 48002)$

8.43	1768
8.44	939
8.45	109 ← SAY OK (PROGRAM 8.46)
8.46	-723 (BOWLES 8.5)

FROM $\Sigma F_H = 0$: AF = 9009.25 (PROGRAM 9015 LB)
(BOWLES 9.1 KIP)

B21

MAXIMUM MOMENT FOR FREE EARTH METHOD
MAXIMUM BETWEEN POINTS C AND C   FIGURE SHEET 1 OF
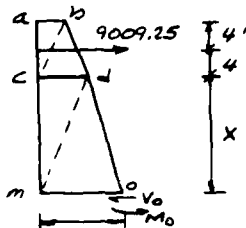
$$P_x = (500 + 8(105) + 66x) K_a = 398.38 + 19.62x$$

FORCE	PRESS DIAG	FACTORS	MOMENT ARM ABOUT O	MOMENT ABOUT O
P1	abc	594.60	$x + 5.33$	$3169.22 + 594.60x$
P2	bcd	1573.52	$x + 2.67$	$4201.30 + 1573.52x$
P3	cdm	$398.38 (x)/2 = 199.19x$	$0.67x$	$133.46x^2$
P4	dmo	$(398.38 + 19.62x)(x)/2 = 199.19x + 9.81x^2$	$0.33x$	$65.73x^2 + 3.24x^3$
AF		-9009.25	$x + 4$	$-36037 - 9009.25x$

$$V_o = -\Sigma P = 6841.13 - 398.38x - 9.81x^2$$

$$M_o = -\Sigma M = 28666.48 + 6841.13x - 199.19x^2 - 3.24x^3$$

$$\text{FOR } V_o = 0 \qquad x = \frac{398.38 \pm \sqrt{(398.38)^2 - 4(-9.81)(6841.13)}}{2(-9.81)} = 13.01'$$

$$M_o = M_{MAX} = 76820^{\#-FT} (PROGRAM \ 76537)$$

DESIGN BY EQUIVALENT BEAM METHOD
ASSUME POINT OF INFLECTION AT POINT 9   FIGURE SHEET 1
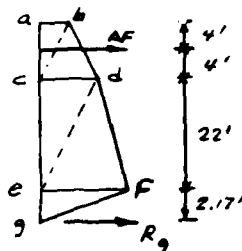
FORCE	PRESS. DIAG.	FACTORS	MOMENT ARM ABOUT AF	MOMENT ABOUT AF
F_1	abc	594.60	-1.33	-790.82
F_2	bcd	1573.52	1.33	2092.78
P_3	cde	4382.18	11.33	49650.10
P_4	def	9130.66	18.67	170469.42
F_5	efg	$(830.06)(2.17)/2 = 900.62$	26.72	24064.57
ΔF		$-\Delta F$	0	0
R_9		$-R_9$	28.17	$-28.17 R_0$

$\Sigma F_H =$ $16581.58 - \Delta F - R_9$

$\Sigma M_{AF} =$ $245486.05 - 28.17 R_9$ $\therefore R_9 = 8714.45^\#$
$\Delta F = 7867.13^\#$
(PROGRAM 7885$^\#$)

PENETRATION BY EQUIVALENT BEAM METHOD

$R_g = 8714.45$

Y
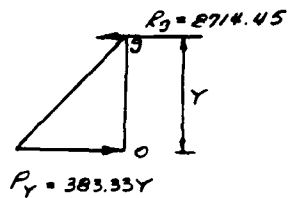
$P_Y = 383.33Y$

$\Sigma M_0 = 8714.45\,Y - (383.33Y)(Y/2)(Y/3) = 0$

$\therefore Y = 11.68'$

$d = 11.68 + 2.17 = 13.85'$ (PROGRAM 13.8')

MAXIMUM MOMENT FOR EQUIV. BEAM METHOD
USE FACTORS FROM FREE EARTH METHOD WITH $4F = 7867.13°$

$V_0 = 5699.01 - 398.38X - 9.81X^2$

$M_0 = 24098.00 + 5699.01X - 199.19X^2 - 3.24X^3$

FOR $V_0 = 0$ $X = \dfrac{398.38 \pm \sqrt{(398.38)^2 - 4(-9.81)(5699.01)}}{2(-9.81)}$

$X = 11.21'$

$M_0 = M_{MAX} = 58387^{\#-FT}$ (PROGRAM 58348 $^{\#-FT}$)

B24

DESIGN BY EQUAL MOMENT METHOD
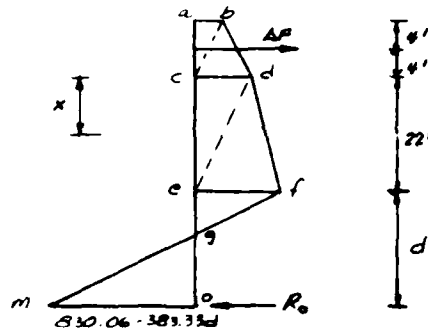
FROM FREE EARTH METHOD AND ABOVE

$$\Sigma M_{AF} = 221421.48 + 21581.56d - 4568.39d^2 - 128.42d^3 + (26+d)R_0 = 0 \quad \text{①}$$

$$\Sigma F_H = 1568076 + 830.06d - 191.67d^2 - AF + R_0 = 0 \quad \text{②}$$

MAXIMUM MOMENT ABOVE e FROM FREE EARTH METHOD

$$\text{MAX OCCURS AT} \quad X = \frac{398.38 - \sqrt{(398.38)^2 - 4(-9.81)(-2168.12 + AF)}}{2(-9.81)} \quad \text{③}$$

$$M_{MAX\,1} = 4AF - 7370.52 + (AF - 2168.12)X - 199.19X^2 - 3.24X^3 \quad \text{④}$$

FOR MAXIMUM MOMENT BELOW e
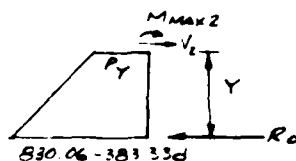
$$P_Y = 830.06 - 383.33(d-Y)$$

$$\text{FOR } V_2 = 0 \quad [830.06 - 383.33(d-Y)]Y/2 + [830.06 - 383.33d]Y/2 + R_0 = 0$$

$$\text{OR } Y = \frac{383.33d - 830.06) \pm \sqrt{(383.33d - 830.06)^2 - 4(191.67)R_0}}{2(191.67)} \quad \text{⑤}$$

THEN
$$M_{MAX\,2} = (415.03 - 191.67d + 127.78Y)Y^2 \quad \text{⑥}$$

PROCEDURE FOR DETERMINING d BY EQUAL MOM. METHOD

1. ASSUME d
2. CALCULATE R_o FROM EQN ①
3. CALCULATE ΔF FROM EQN ②
4. CALCULATE X FROM EQN ③
5. CALCULATE M_{MAX1} FROM EQN ④
6. CALCULATE Y FROM EQN ⑤
7. CALCULATE M_{MAX2} FROM EQN ⑥
8. REPEAT UNTIL $|M_{MAX1}| = |M_{MAX2}|$

TRIAL d	R_o	ΔF	X	M_{MAX1}	Y	M_{MAX2}
13'	14159.36	8238.87	11.81	64161	4.24	-27594
14'	18105.64	7840.12	11.17	57978	5.08	-41786
15'	23348.37	7381.48	10.66	53369	5.90	-59390
14.73'	21171.88	7492.43	10.60	52797	5.68	-54281
14.67	20913.99	7522.84	10.65	53242	5.63	-53167 OK

(PROGRAM d = 14.65', ΔF = 7502", M_{MAX} = 52628 "')

* INTERPOLATE

d = 14' $M_{MAX1} + M_{MAX2}$ = 16192

d = 15' $M_{MAX1} + M_{MAX2}$ = -6021

d = 14 + 16192 / (16192 + 6021) = 14.73

d = 14' $M_{MAX1} + M_{MAX2}$ = 16192

d = 14.73' $M_{MAX1} + M_{MAX2}$ = -1484

d = 14 + 0.73 [16192 / (16192 + 1484)] = 14.67

B26

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